Issued June 23, 1910.

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF SOILS—BULLETIN No. 69.

MILTON WHITNEY, Chief.

A REVIEW OF THE PHOSPHATE FIELDS OF IDAHO, UTAH, AND WYOMING.

WITH SPECIAL REFERENCE TO THE THICKNESS AND QUALITY OF THE DEPOSITS.

BY

W. H. WAGGAMAN.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1910.

BUREAU OF SOILS.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Soils,
Washington, D. C., February 2, 1910.

Sir: I transmit herewith the manuscript of an article entitled "A Review of the Phosphate Fields of Idaho, Utah, and Wyoming, with Special Reference to the Thickness and Quality of the Deposits," by W. H. Waggaman, of this Bureau. I have the honor to recommend that this article be published as Bulletin No. 69 of the Bureau of Soils.

Very respectfully,

Milton Whitney,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

PREFACE.

One of the lines of work in progress in the Bureau of Soils is the investigation of phosphatic fertilizers. Important contributions to our knowledge of the chemistry of the phosphates of lime, iron, and alumina have been made in the laboratories and the results have been published in Bulletin No. 41, Bureau of Soils, United States Department of Agriculture, 1907. Further work along this line is now in progress. Experiments upon the cultural value of phosphatic fertilizers have also been conducted, and the large mass of evidence furnished by the field and plot investigations of American and foreign experiment stations has been collected and classified.

It is obviously of importance that a detailed and comprehensive knowledge of existing phosphate deposits, especially American deposits, should also be available. This office has welcomed, therefore, the opportunity to cooperate with the United States Geological Survey in studying one of the largest and potentially most valuable deposits in the world. The present bulletin is a contribution to our knowledge of this deposit, prepared with the agricultural interests involved primarily in view. While further field work on American deposits is now in progress, it is believed desirable to publish at the present time the results contained in the following pages, owing to the active public interest in the subject.

FRANK K. CAMERON,
In Charge of Physical and Chemical Investigations.

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A REVIEW OF THE PHOSPHATE FIELDS OF IDAHO, UTAH, AND WYOMING.

INTRODUCTION.

In some of our Western States there is a deposit of phosphate rock extending over a large area—in fact, one of the largest phosphate areas now known in the world. This region, so far as yet explored, comprises portions of northeastern Utah, southeastern Idaho, and southwestern Wyoming. The area in these States underlain with phosphatic rocks exceeds the phosphate areas of Florida and Tennessee, and it compares favorably with the large phosphate fields of northern Africa in Tunis, Algiers, Oran, and Morocco. Not only are these western deposits extensive in area, but the phosphate occurs in thick, readily workable beds, and chemical analyses of the rocks show them to be of high grade. Thus the favorable conditions of quality, thickness, and area of workable beds make these western phosphate deposits a valuable national asset.

Interest in these lands has been stimulated by the recent conservation movement, since phosphate rock is generally considered to be one of the natural resources which is apparently being most rapidly depleted. The Secretary of the Interior, by order of December 9, 1908, and subsequent orders in the spring of 1909, withdrew from all form of entry some 6,700 square miles of the public domain in western Wyoming, eastern Idaho, and northeastern Utah. This area included most of the lands known to contain workable phosphate deposits near the surface, and possibly also at reasonable depths. These withdrawals were made on the basis of the then available geological data, which were more or less meager. Consequently, the Department of the Interior sent out two Geological Survey parties in the summer of 1909 to classify these lands according to their value in phosphate rock, so that the nonphosphatic portions could be restored to possible agricultural entry. By previous arrangement with the Department of Agriculture the writer was assigned to assist in the work as chemist.

One party, comprising Prof. Eliot Blackwelder and Mr. Jessup, both of the University of Wisconsin, worked in several townships in the southwestern corner of the area, from the vicinity of the Devils

Slide, Croydon, and Morgan, on the Union Pacific Railroad, northward through Huntsville and Eden, in Morgan and Weber counties, Utah. The main party comprised Mr. Hoyt S. Gale, in charge, assisted by Messrs. Ralph W. Richards and Carpel L. Breger, all of the United States Geological Survey, and with this party the writer was stationed throughout the season. For two months the party was assisted by Dr. George H. Girty, of the United States Geological Survey, expert on the Carboniferous systems which include the rock formations containing the phosphate. It was of obvious advantage to the parties to have immediate information regarding the value of the lands surveyed. Consequently all the analyses, some 340 in number, were made in the field with a portable laboratory outfit. Owing to the distance separating the respective parties of Mr. Gale in the Bear River Valley and of Professor Blackwelder in the Salt Lake district, it was impracticable to render immediate assistance to the latter, but various samples were analyzed from time to time as they arrived. At the close of the field season the writer went to San Francisco and Los Angeles to inspect the plants manufacturing the phosphate rock into fertilizers.

The present report contains the results of work in the season of 1909 on the sampling and analyses of the phosphate rock, together with some notes on the processes of its manufacture into superphosphate and mixed fertilizers, and on the present status of the industry in general so far as the western phosphate field is concerned. A report dealing at length with the geology of the phosphate area will be published by the Geological Survey in the near future.[a]

LOCATION OF THE FIELDS.

Only a small proportion of the total phosphate withdrawals was examined in 1909. The present report includes only those portions of Bear Lake County, Idaho, Uinta County, Wyo., and Rich County, Utah, which were examined by the party in charge of Mr. Gale during the past season. The principal areas so examined comprise: (1) The east side of Bear Lake Valley from Georgetown, Bennington, and Montpelier, Idaho, southward through Dingle, Hot Springs, North Eden and South Eden canyons, to Laketown, Utah, and continuing southerly beyond Randolph and Woodruff, Utah, to the phosphate prospects near the head of Twelve-mile Creek, near the southwest corner of Rich County, Utah; and (2) the Sublette-Crawford Mountains belt, comprising the Sublette Mountain range from north of Raymond Canyon, southward through Cokeville,

[a] Gale, Hoyt S., and Richards, Ralph W., Preliminary Report on the Phosphate Deposits in Southeastern Idaho and Adjacent Parts of Wyoming and Utah: Bul. U. S. Geol. Survey No. 430, 1910.

Wyo., through the Beckwith Hills and Sage, Wyo., and through the Crawford Mountains along the Utah-Wyoming border.

ACCESSIBILITY.

The phosphate rock occurs as a bedded deposit interstratified with the limestones and quartzites found commonly in the higher hills and mountain chains of the region. Only in the Beckwith Hills area north of the Crawford Mountains, and near Cokeville, do the phosphate rocks come down to the larger valley bottoms within a mile of the railroad. Elsewhere, however, though occurring in the higher ranges, the phosphate rock is within easy access of possible spurs from the Oregon Short Line Railroad. At present the phosphate mined in the Georgetown, Montpelier, Cokeville, and Crawford Mountain areas is hauled by wagon for 8, 4, 1½, and 5 miles, respectively.

GEOLOGIC OCCURRENCE OF THE PHOSPHATE BEDS.

GENERAL STATEMENT.

A study of the phosphate beds of the Idaho, Utah, and Wyoming fields, and of the relation of the ores to the series of stratified rocks in which they are interbedded, shows them to be original sedimentary deposits. Although the original deposits may have been altered later by secondary chemical processes, so that recrystallization, enrichment, or impoverishment of certain strata have taken place, nevertheless there is sufficient evidence to indicate that such action has been of minor importance. The phosphate deposits are a part of a great series of sedimentary strata, deposited at a time when this part of the earth's surface was submerged. Following the deposition of these beds, other deposits were similarly formed to a thickness of many thousands of feet, and subsequent deformation of the earth's crust folded and broke the originally flat-lying strata. Thus the rock phosphate ores are, in the manner of their occurrence and origin, more properly analogous to deposits of coal or limestone, and especially to the sedimentary Clinton iron ores of the Appalachian region, than they are to those ore deposits formed in veins, lodes, shoots, or in alluvial deposits of the placer type.

ASSOCIATED FORMATIONS.

The phosphate ores of this general region occur in rocks of Carboniferous age, as may be seen from the following summary of the geologic formations, which are more or less directly related to the study of these deposits:

Jurassic-Cretaceous	Beckwith formation.
Jurassic	Twin Creek limestone.

Jurassic of Triassic		Nugget sandstone.
Triassic or Carboniferous		Ankareh shale.
		Thaynes limestone.
		Woodside shale.
Carboniferous	Pennsylvanian	Park City formation (including the phosphate beds).
		Weber quartzite.
	Mississippian	(not differentiated as formations).

STRUCTURAL RELATIONS.

The study of the phosphate rocks themselves necessarily includes the consideration in some detail of both overlying and underlying stratigraphic formations to the extent that the associated rocks will be useful in tracing both outcrop and underground position of the more valuable beds. The total thickness of the strata in which the phosphate occurs is generally not greater than 200 feet. Exposures of these beds present very definite characteristics, and are remarkably constant for great distances (judging from present knowledge of these fields). The fossils associated with the phosphate beds and found in the overlying and underlying strata are in many places valuable guides in determining the position and depth of the phosphate series below the surface. If the phosphate beds were in their original horizontal position, with the succeeding formations deposited upon them in normal horizontal position, the thickness of the beds would be a measure of the depth of the workable deposits. Wherever these beds become tilted and folded, an additional factor must be introduced into the computation of the position and depth of the phosphate layer.

The phosphatic beds constitute a part of a geological formation known as the Park City, the nature and composition of which is described in more detail in the consideration of the various localities where the deposits have been studied. One of the best exposed sections observed during the season's work is in the Georgetown area in the Preuss Range, described on pages 13 and 14 of this report. This may be taken in a general way as representative of the character and succession of these beds as elsewhere found, although details such as thickness and phosphatic content of individual beds vary from place to place. The phosphate-bearing zone is composed chiefly of a brown or dark-colored shale, with bands of limestone and beds of so-called oolitic or pebbly phosphate rock, which, being higher in phosphate, constitute the workable deposits. While the phosphatic section in the Georgetown district appears to be only 140 feet thick, other localities, chiefly toward the south, have shown thicknesses of a corresponding section ranging up to 250 or perhaps 300 feet. A summary of this representative section is here given as a typical section:

TABLE I.—*Section of the phosphate-bearing beds near Preuss or Mead Peak, Idaho.*

No.	Field No. 144.	Description.	P_2O_5.	Thickness.
			Per cent.	*Ft. in.*
1	A	Shale, brown weathering calcareous, irregular chip fragments	3.5	25 6
2	B, C, D	Phosphate rock, pebbly or oolitic, brown or gray weathered	28.9	4 5
3	E, F	Shale, phosphatic, brownish, somewhat pebbly, earthy composition.	13.2	2 5
4	G, H, I	Phosphate rock, alternating layers of fine to coarse pebbly rock.	33.2	10 10
5	K, L, M, N	Shale, phosphatic (including limestone, dark, compact, fine-grained—not sampled; 1 foot 9 inches), mostly dark-brown earthy composition.	17.2	51 6
6	O	Shale; phosphatic, dark-brown, earthy (containing 4 feet lime stone—not sampled).	21.2	12 0
7	P, Q, R	Shale; phosphatic, dark-brown, including 11 inches limestone (not sampled).	23.5	23 0
		Limestone; massive, fossiliferous (not sampled)		3 2
8	S	Phosphate rock (main bed), fine to medium grained pebbly texture; dark-brown or black color.	36.8	6 4
9	T	Shale, phosphatic, brown, earthy composition	3.7	0 9
10		Limestone, massive, thickness not determined		
	Total			139 11

The zone, including the phosphatic beds, is normally overlain by a massive cherty limestone, locally referred to as the "cherty lime" or Productus limestone, the latter name derived from the common occurrence in the rock of a fossil brachiopod shell of the genus *Productus*. From the resistant character of this rock and its prominence in ledges, it is a useful guide in indicating the position of the underlying phosphate beds. Underlying the workable phosphate beds and associated phosphatic shales, a massive bedded limestone of fine to coarse granular composition is normally found. This rock is of pale bluish color on the weathered surfaces or in freshly broken faces, and is more or less arenaceous or siliceous. This has been locally described as the "underlying lime."

Estimates of the depth to which the valuable deposits extend are based upon the character, thickness, and continuity of overlying strata as they are revealed in outcrops, and for this reason a somewhat careful study of the formations immediately overlying the Productus limestone was made. Next in the geologic column are the Woodside, Thaynes, and Aukareh formations, which, without entering into a discussion of the minor subdivisions and characteristics or of the included fossils, may be described as composed in the lower part of brownish weathering sandy or muddy limestones, usually of shaly bedded structure, and of reddish shale to a thickness of a few hundred feet, and in the upper part of alternating strata of blue weathered limestone, brownish weathered sandstone, and sandy shale, including reddish shales near the top. The thickness of the Woodside, Thaynes, and Aukareh formations is about 3,000 feet. Succeeding this group comes another formation of great thickness, described in a report on Wyoming coal fields,[a] which

[a] Veatch, A. C., Geography and Geology of a Portion of Southwestern Wyoming, U. S. Geological Survey. P. P. No. 56, 1907.

lie adjacent to this territory, as the Nugget formation. This is approximately 2,500 feet thick, and is composed mainly of coarse red and white sandstone, very massive, and at times strongly cross-bedded. Above the Nugget are found thin-bedded and shaly limestones, described as the Twin Creek formation in the report above referred to. This formation also has a thickness of several thousand feet.

DESCRIPTION OF THE FIELD METHOD FOR DETERMINING PHOSPHORIC ACID.

All the analyses in the following tables were made in the field, though occasionally the results were checked by analysis in the laboratory of the Bureau of Soils at Washington, D. C. The apparatus for chemical work was made of the most compact and durable materials obtainable, and the chemicals employed were, so far as possible, carried in solid form in order to minimize the danger of loss in transportation.

Average samples representing each stratum of any importance in the phosphate series were obtained by chipping off pieces from a clean surface, beginning at the top and working down at right angles across the strike of the beds. The weight of the samples ranged from one-half pound to 4 pounds, depending on the thickness of the beds. Each sample was crushed on the small bucking board, quartered down, pulverized in the small porcelain mortar, and finally put through the sieve. During damp weather, or when the samples were collected from prospects wet from percolating water, they were dried in an oven, but in these normally dry regions this was seldom necessary.

Two grams of the sample were weighed and brushed into an enameled cup; 25 to 30 c. c. of water (not distilled) were added and 10 c. c. of concentrated nitric acid. The cup was covered with a watch glass, placed on the stove, and the contents allowed to digest for seven or eight minutes. After cooling somewhat, the insoluble material was filtered off, washed thoroughly on the filter, and the filtrate made up to 200 c. c. with water (not distilled). An aliquot (10 c. c. or 20 c. c., depending on the amount of P_2O_5 present) was then taken for analysis. This was diluted with 20 to 30 c. c. of water, a few cubic centimeters of saturated solution of ammonium carbonate added, and sufficient nitric acid to render the solution acid to litmus paper. The cup was then returned to the stove, heated to 70° or 80° C., and 25 c. c. of ammonium molybdate solution added, drop by drop, with constant stirring. After standing ten minutes the solution above the precipitate of ammonium phosphomolybdate was decanted and filtered and the precipitate washed as far as possible by decantation until the washings gave no acid

reaction. Distilled water was used in this last operation. The filter was then returned to the cup, a little distilled water was added, and a standard solution of potassium hydroxide was added until the yellow precipitate dissolved. Standard nitric acid (matched against the potash solution) was run in from a burette, drop by drop, until the pink color of the indicator—phenolphthalein—disappeared. The quantity of nitric acid used, subtracted from the amount of potassium hydroxide gave the number of cubic centimeters of the latter solution required to dissolve the yellow precipitate. The potassium hydroxide was of such strength that 1 c. c. equaled 1 milligram of phosphoric acid (P_2O_5). This solution was standardized against acid potassium sulphate ($HKSO_4$). The latter, being a solid, can be readily transported without danger. Definite charges were weighed out in the laboratory before starting for the phosphate area, and these were made up to 200 c. c. as required. When the solution from a 2-gram sample of phosphate is made up to 200 c. c. and 10 c. c. aliquots are used for analysis, all calculations are avoided, for the percentage of phosphoric acid present is the same as the number of cubic centimeters of potassium hydroxide necessary to dissolve the precipitate. If a 20 c. c. aliquot is taken, the amount of potassium hydroxide employed, divided by 2, gives the percentage of phosphoric acid present.

It was found that after the samples were quartered down, it was possible to run through twenty determinations during the day. The results could usually be duplicated within 0.5 of 1 per cent of the actual quantity of phosphoric acid present.

The analytical results given in the tables and text in following pages are expressed both as phosphoric acid and tricalcium phosphate ($Ca_3(PO_4)_2$). Although the phosphoric acid in the rock is by no means present as tricalcium phosphate, the results have been so calculated, the usual commercial valuations being made on that basis. As a matter of fact, from a chemical standpoint, it is doubtful if such a compound as tricalcium phosphate exists.[a]

IDAHO.

GEORGETOWN AREA.

On the east side of Bear River, in the middle of the Preuss Mountains—a range extending north and south for a distance of 30 miles—there is a deep gulch known as Georgetown Canyon. Six to 8 miles from the mouth of this canyon the phosphate is exposed along the steep slopes which extend down from Preuss Peak and the high ridge to the north. The geological structure is somewhat complex. The phosphate deposits occupy the trough of a syncline to the north and

[a] Cameron and Bell, Bul. No. 41, Bureau of Soils, U. S. Dept. Agr., pp. 17–20.

west of Preuss Peak, but this structure is complicated by further folding and tilting, and erosion has removed much of the valuable rock, especially at the southern end of the phosphate properties.

The Utah Fertilizer and Chemical Company has located a number of claims in this region. The main phosphate bed is at the base of the phosphate series, is directly overlain by a fossiliferous limestone, and has practically the same horizon and thickness as at Montpelier, 16 miles south. This bed was sampled at three different points quite widely separated and having very different dips and strikes. The phosphate content of all three, however, was nearly the same.

On one of the "Highland" claims, at the foot of the high ridge which extends north from Preuss Peak, there is an open cut running east and west across the strike and exposing the entire phosphate series. The beds stand nearly vertical, but dip steeply toward the east. Samples representing about 140 feet of the different strata were collected along this cut.

Above the main bed there are five other beds of high-grade phosphate rock in this series. Beginning with the uppermost they occur as follows: 25 feet under the Productus limestone is a 6-inch stratum (No. 144–B) containing 35.8 per cent phosphoric acid, or 78.4 per cent tricalcium phosphate. Under this and separated from it by only 1 foot of calcareous shale is a 2-foot 11-inch stratum (144–D) containing 37.6 per cent phosphoric acid, or 82.3 per cent tricalcium phosphate. Only 2 feet 5 inches under this second phosphate stratum is a third bed (144–G) made up of seven strata aggregating 4 feet 2 inches in thickness and containing 33.3 per cent phosphoric acid, or 72.9 per cent tricalcium phosphate. Directly under this is a fourth bed (144–H) consisting of alternating bands of oolitic rock and shaly phosphate, the whole being 1 foot 10 inches thick and containing 29.3 per cent phosphoric acid, or 64.1 per cent tricalcium phosphate. Below this is a fifth bed (144–I) consisting of phosphate rock and phosphatic shales, aggregating 4 feet 10 inches and containing 34.7 per cent phosphoric acid, or 76 per cent tricalcium phosphate.

The next bed of high-grade rock is that at the base of the series (144–S), and corresponds with that mined at Montpelier, Idaho. It is overlain by the same fossiliferous limestone found in the Montpelier area. It is 90 feet 2 inches below No. 144–I, and is from 6 to 7 feet in thickness. The samples from three different localities give an average of 36.5 per cent phosphoric acid, or 79.9 per cent tricalcium phosphate. The three consecutive beds, 144–G–H–I, have a total thickness of 10 feet 10 inches, averaging more than 70 per cent tricalcium phosphate, and could readily be mined together.

As can be seen from inspection of Table I, there are several thick beds of high-grade phosphatic shales in this section. Nos. 144–N–O–P–Q taken together give a bed 42 feet 2 inches in thickness,

containing an average of 23.6 per cent phosphoric acid, or 51.6 per cent tricalcium phosphate.

Since much of the phosphate which is accessible occurs high up the slopes, tramways will have to be constructed to bring the material to the road at the bottom of the canyon. The timber in this section, however, right at hand, will minimize the cost of these tramways and should also prove a valuable asset in the actual mining of the phosphate. The creek at the bottom of the gulch might also be utilized for water power. The long haul to the railroad, a distance of 11 or 12 miles, will be the most expensive part of the mining operations in this region. Now assessment work only is being done on claims in this area.

The following abbreviations are used in the tables giving the results of chemical analyses:

b=black.
br=brown.
br b=brownish black.
brit=brittle.
cal=calcareous.
con=considerable.
crm=crumbly.
crs=coarse.
eff=effervescence.
gr=gray.
gr b=grayish black.
gr br=grayish brown.
h=hard.
ls=limestone.
mas=massive.
med=medium
ool=oolite.
phos=phosphate or phosphatic.
s=soft.
sh=shale or shaly.
vig=vigorous.
w=weathered.
yel=yellow.

The analytical results for the Georgetown area are given in Table II.

TABLE II.—*Results of chemical analyses of phosphate rocks in the Georgetown area, Idaho.*

[Series from long cut running almost east and west across strike. Exposure of 140 feet of series in what would be section 30, township 10 south, range 44 east, Boise meridian. (Unsurveyed land.)]

Sample No.	Strike.	Dip.	Thickness of strata.	Distance below Productus limestone.	Description.[a]	P_2O_5.	$Ca_3(PO_4)_2$.
			Ft. in.	*Ft. in.*		*Per cent.*	*Per cent.*
144-A	N. and S..	85° to 90° E...	25 6	0 0 to 25 6	Sh, br, cal, t, eff vig	3.5	7.7
144-B	N. and S..	85° to 90° E...	0 6	25 6 to 26 0	Ool, mcd, gr, w, eff slight	35.8	78.4
144-C	N. and S..	85° to 90° E...	1 0	26 0 to 27 0	Sh, h, br, cal, eff vig	Trace.	Trace.
144-D	N. and S..	85° to 90° E...	2 11	27 0 to 29 11	Ool, crs, gr, brit, eff vig	37.6	82.3
144-E	N. and S..	85° to 90° E...	1 0	29 11 to 30 11	Sh, s, ycl, eff con	10.0	21.9
144-F	N. and S..	85° to 90° E...	1 5	30 11 to 32 4	7″ ool, crs, gr, brit 6″ ool, mcd, not h } eff con 4″ sh, phos, br...	21.9	48.0
144-G	N. and S..	85° to 90° E...	4 2	32 4 to 36 6	1′ 2″ ool, crs, gr, brit 4″ ool, fine, br gr 2″ ool, crs, gr b 4″ ool, fine, br gr } eff slight 7″ ool, crs, gr, cr 3″ ool, fine, b 1′ 4″ ool, crs, brit, gr	33.3	72.9
144-H	N. and S..	85° to 90° E...	1 10	36 6 to 38 4	7″ ool, med, gr 10″ sh, phos, t, br } eff slight 2″ ool, crs, gr 3″ sh, phos, t, br	29.3	64.1
144-I	N. and S..	85° to 90° E...	4 10	38 4 to 43 2	1′ 1″ ool, crs, br 5″ sh, phos, br, s 4″ ool, crs, gr, s } eff con 3′ ool, crs to med	34.7	76.0
144-K	N. and S..	85° to 90° E...	8 9	43 2 to 51 11	Sh, br b, s, br t, eff slight	24.2	53.0
	N. and S..	85° to 90° E...	1 9	51 11 to 53 8	Ls (not sampled)		
144-L	N. and S..	85° to 90° E...	12 0	53 8 to 65 8	Sh, br b, mostly s, eff slight	11.7	25.6
144-M	N. and S..	85° to 90° E...	17 0	65 8 to 82 8	7′ sh, br b, mostly s 4′ 7″ concealed (probably same) } eff slight 5′ 5″ sh, br b, s	15.1	33.1
144-N	N. and S..	85° to 90° E...	12 0	82 8 to 94 8	Sh, b, s, eff slight	19.9	43.6
144-O	N. and S..	85° to 90° E...	12 0	94 8 to 106 8	4′ sh, br b, s, brit. 2′ ls (not sampled) 4′ sh, br b, s, brit. 2′ ls (not sampled)	21.2	46.4
144-P	N. and S..	85° to 90° E...	6 2	106 8 to 112 10	Varies from cal, h, b to s, b, eff con	25.8	56.5
144-Q	N. and S..	85° to 90° E...	12 0	112 10 to 124 10	Varies from sh, cal, h to s, b, eff con	24.6	53.9
144-R	N. and S..	85° to 90° E...	4 10	124 10 to 129 8	Ls, sh, br gr, brit, eff very vig	17.8	39.0
	N. and S..	85° to 90° E...	0 11	129 8 to 130 7	Ls (not sampled)		
	N. and S..	85° to 90° E...	2 3	130 7 to 132 10	Ls, cap lime (not sampled)		
144-S	N. and S..	85° to 90° E...	6 4	132 10 to 139 2	Ool, crs to med, brit, w, eff slight (main bed)	36.8	80.6
144-T	N. and S..	85° to 90° E...	0 9	139 2 to 139 11	Sh, br, s, brit, eff slight	3.7	8.1

[a] The abbreviations used in this column are explained on page 15.

MONTPELIER AREA.

Fifteen or 16 miles farther south in the Preuss Range and northeast of the town of Montpelier, Idaho, the phosphate is again exposed, and considerable prospecting has been done at various points. The phosphate rock here is black, in part oolitic, and varies in hardness, though it can all be easily crushed. The main bed at the base of the phosphate series, as at Georgetown, is 6 feet thick and contains an average of 34 per cent phosphoric acid, or 75 per cent tricalcium phosphate. It is overlain by 4 feet of fossiliferous limestone (Table III, No. 9) containing 6 per cent of phosphoric acid, and underlain by a low-grade phosphatic shale (No. 22), which varies from 1 inch to 9 inches in thickness. Under this shale there is another thick stratum of limestone (No. 10) containing but a trace of phosphoric acid. The phosphatic shales above the main bed, and separated from it by the fossil limestone (about 30 feet were sampled) average about 15 per cent phosphoric acid or 33 per cent tricalcium phosphate. These shales are quite soft and can be removed with a spade. They have the appearance and texture of a rich, loamy soil.

Although analysis shows that the phosphate rock having distinctly oolitic structure usually contains a much higher percentage of phosphoric acid than the close-grained, more shaly materials, yet in some cases the shales show quite a high content of phosphoric acid. (See Table III, No. 32.) Weathering tends to increase the percentage of phosphoric acid present in the phosphate rock, since the carbonate of lime is leached out more rapidly than the phosphates. Weathered specimens are also much more readily crushed, falling to pieces from a light blow of the hammer. No good exposures of the phosphate series could be obtained in township 13 south, range 45 east, Boise meridian, but the main bed was sampled in a number of places, and, as can be seen from the results given in Table III, it contains an approximately constant quantity of phosphoric acid throughout. The San Francisco Chemical Company owns and operates a patented placer claim, called the Waterloo, 4 miles east of the town of Montpelier. This claim has been developed by quarrying, tunneling, and shafting. The phosphate beds have a dip of about 30° W., so that the stoping system of mining has been employed. The rock is removed by picks and run from the upper levels by means of chutes into standard ore cars. These cars are then pushed from the main tunnels and their contents dumped into storage bins outside the mine. From the bins the material is loaded into wagons and hauled 4 miles to Montpelier, on the Oregon Short Line Railroad, which carries it to the fertilizer factories at San Francisco, Cal.

The cost of mining the material is estimated at approximately $1.50 per ton. Haulage to railroad is 75 cents per ton, and freight

rates from Montpelier to the coast are about $4.20 per ton. The rock is salable in limited quantities at Montpelier at about $2.50 per ton f. o. b. This apparently leaves a very narrow margin of profit for the mine owners. This same company has a number of other claims about Montpelier, but from none of these have shipments been made.

The analytical data for the Montpelier area are given in Table III.

TABLE III.—*Results of chemical analyses of phosphate rocks in the Montpelier area.*

[Townships 12 and 13 south, range 44 east, Boise meridian, Idaho.]

Sample No.	Location.	Strike.	Dip.	Thickness of strata.	Distance below Productus limestone.	Description.[a]	P_2O_5.	$Ca_3(PO_4)_2$.
				Ft. in.			*Per cent.*	*Per cent.*
29	First prospect SE. of Prospect Mountain, ridge W. of gulch, NW. ¼ SE. ¼ sec. 30, township 12.	N. and S.	24° W.	4 9	Not determined.	Ool, br b, s, eff slight	33.5	73.4
30	First prospect on N. side of Phosphate Gulch, SW. ¼ SE. ¼ sec. 30, township 12.	N. 65° E.	20° W.	4 8	Not determined.	Sh, phos, br b, w, eff slight	34.2	74.9
31-A	First prospect on S. side of Phosphate Gulch, NW. ¼ NE. ¼ sec. 31, township 12.	N. 32° E.	35° W.	4 5	Not determined.	Sh, phos, gr br, s, eff con	35.3	77.3
32	Prospect S. of 31-A, on S. side of Phosphate Gulch, NW. ¼ NE. ¼ sec. 31, township 12.	N. 32° E.	35° W.	5 0	Not determined.	Sh, br, s, w, eff slight	30.6	67.0
33	Prospect S. of 32, on S. side of Phosphate Gulch, NW. ¼ NE. ¼ sec. 31, township 12.	N. 32° E.	35° W.	4 10	Not determined.	Varies from ool, br to sh, br	34.4	75.1
28-A	Series above main phosphate bed, taken from exposure N. of Montpelier waterworks, SW. ¼ SE. ¼ sec. 31, township 12.	N. 32° E.	36° W.	2 4	Not determined.	Sh, br, s, eff con	14.8	32.4
28-B [b]	do	N. 32° E.	36° W.	1 6	Not determined.	Ls, br, h, eff very vig	2.6	5.7
28-C [b]	do	N. 32° E.	36° W.	5 0	Not determined.	Sh, br, s, eff slight	16.6	36.4
28-E [b]	do	N. 32° E.	36° W.	6 0	Not determined.	Sh, b, s, eff slight	12.6	27.6
	do	N. 32° E.	36° W.	5 0	Not determined.	Concealed (probably same as above)		
28-F [b]	do	N. 32° E.	36° W.	2 0	Not determined.	Sh, b, s, eff slight	12.0	26.3
28-G [b]	do	N. 32° E.	36° W.	4 0	Not determined.	Sh, b, s, eff slight	[c] 5.7	12.5
5	Sample from Waterloo mine (San Francisco Chemical Co.) lower entry, near N. end, SW. ¼ sec. 6, township 13.	E. of N.	30° W.	5 0	Not determined.	Ool, b, med h, eff con (main bed)	34.8	76.2
6-A	Sample from Waterloo mine 50 feet from lower entry, SW. ¼ sec. 6, township 13.	E. of N.	30° W.	1st foot.	Not determined.	Ool, b, h, eff vig } main bed	36.1	79.1
6-B	do	E. of N.	30° W.	3d foot.	Not determined.	Ool, b, h, eff slight } main bed	34.5	75.6
6-C	do	E. of N.	30° W.	5th foot.	Not determined.	Ool, b, med h, eff con } main bed	34.0	74.5
8	Sample from upper entry Waterloo mine, 240 feet from entry, SW. ¼ sec. 16, township 13.	E. of N.	30° W.	5 0	Not determined.	Ool, med h, br b, eff con	35.2	77.1
14	Sample from prospect NW. ¼ SE. ¼ sec. 30, township 12.	E. of N.	30° W.	4 6	Not determined.	Ool, med h, br b, eff con	36.1	79.1
21	Sample from Waterloo claim prospect above and E. of main mine, SW. ¼ sec. 16, township 13.	E. of N.	30° W.	5 10	Not determined.	Ool, med h, gr b, eff con	37.7	82.6
9	Sample of limestone directly overlying main phosphate bed, Waterloo mine, SW. ¼ sec. 16, township 13.	E. of N.	30° W.	4 0	Not determined.	Ls, b, h, fossil, eff vig ("cap lime")	6.1	13.4
22	Samples underlying main phosphate beds, Waterloo mine, SW. ¼ sec. 16, township 13.	E. of N.	30° W.	0 4	Not determined.	Sh, br, s, eff vig	15.6	34.1
10	do	E. of N.	30° W.	Not deter	Not determined.	Ls, gr b, h, eff very vig	Trace.	Trace.

[a] For explanation of abbreviations used in this column see p. 15.

[b] Samples taken consecutively above "cap lime."

[c] Poor sample; contains soil.

HOT SPRINGS AREA.

Another important area in Idaho is near Hot Springs, at the northeast corner of Bear Lake, 16 miles southeast of Montpelier, Idaho. Rising precipitately from the lake shore is a high ridge running parallel to the lake and separated by a broad gulch from the general level of Bear Lake plateau, which forms the high country east of Bear Lake. The phosphate series is exposed on the west side of this gulch, the Productus limestone forming steep, sharp ledges. The series is completely overturned, the Productus limestone dipping under and occurring to the east of the phosphate.

The Union Phosphate Company has done considerable work in this locality. A very good section, representing over 50 feet of the phosphate series, was sampled. In this series there are three thin strata, aggregating 4 feet 4 inches in all, containing over 32 per cent phosphoric acid, but so widely separated as to make mining quite expensive. There is, however, a stratum (141–H) 5 feet 10 inches thick the phosphate content of which falls just a little below that which is commercially considered economical to mine under present conditions. It runs 29.1 per cent phosphoric acid. In places this stratum contains seams of shaly material, which undoubtedly accounts for the lower phosphate content. Directly under this bed is a stratum of pebbly phosphate (141–I) 1 foot 5 inches thick, containing 28 per cent phosphoric acid, and below this stratum there is a bed of black shaly material (141–K) 11 feet in thickness, which contains 24.3 per cent phosphoric acid.

About 1 mile north of this mine are other prospects, only one of which was sampled. Samples representing but 5 feet were obtained here. These samples are of the main beds, which can be traced by intermittent exposures for about 5 miles. The strata of phosphatic shales in this region are so numerous, so thick, and contain in the aggregate so much phosphoric acid that in time they will become of economic importance, although at present many of them have practically no commercial value, since the superphosphate companies in the West consider any material having less than 32 per cent of phosphoric acid not worth handling. Moreover, the amount of iron and alumina present in these shales is objectionably high for the manufacture of superphosphate. These deposits, on the other hand, have the advantage of being easily mined and crushed. The phosphate at Hot Springs is from 4 to 8 miles distant from the Oregon Short Line Railroad at Dingle, Idaho. At present, however, no material is being shipped.

The results of chemical analyses for the Hot Springs fields are given in Table IV.

TABLE IV.—*Results of chemical analyses of phosphate rock in Hot Springs area, Idaho.*

SERIES FROM ONE OF FOUR SHALLOW PROSPECTS, 2 MILES (APPROXIMATELY) SOUTH OF DINGLE, IDAHO.

[Township 14 south, range 44 east, Boise meridian.]

Sample No.	Strike.	Dip.	Thickness of strata.	Distance below Productus limestone.	Description.[a]	P_2O_5.	$Ca_3(PO_4)_2$.
			Ft. in.	*Ft. in.*		*Per cent.*	*Per cent.*
139–A	N. and S..	W.	3 0	20 0 to 23 0	Sh, br, h, eff slight	1.9	4.2
139–B	N. and S..	W.	3 0	23 0 to 26 0	Ool, crs, crm, eff slight	32.8	71.8
	N. and S..	W.	2 6	26 0 to 28 6	Sh & Ool, twisted (not sampled)		
139–C	N. and S..	W.	1 6	28 6 to 30 0	Ool, crs, gr, eff slight	36.5	80.2
139–D	N. and S..	W.	0 5	30 0 to 30 5	Ool, gr, crs, h, pebbly eff slight	38.9	85.2
139–E	N. and S..	W.	0 11	30 5 to 31 4	{ 6″ sh, phos, br h 1″ ool, crs, s 4″ sh, cal, phos } eff slight	28.8	63.1
139–F	N. and S..	W.	3 6	31 4 to 34 10	{ 7″ ool, gr, crs, crm 11″ ool, finer, sh 2′ ool, crs, gr, crm } eff slight	35.8	78.4

SERIES FROM STUART CLAIM (C. C. JONES).

[Section 13, township 15 south, range 44 east, Boise meridian.]

140–A	N. and S..	W.	2 2	Not determined.	Sh, br, cal, eff vig	2.0	4.4
140–B	N. and S..	W.	2 8	Not determined.	Phos, cherty, h, gr br	32.8	71.8
140–C	N. and S..	W.	0 6	Not determined.	Sh, br, h, eff slight	3.0	6.6
140–D	N. and S..	W.	1 2	Not determined.	Sh, br b, h, eff slight	5.9	12.9

[a] The abbreviations used in this column are explained on p. 15.

TABLE IV.—*Results of chemical analyses of phosphate rock in Hot Springs area, Idaho*—Continued.

SERIES FROM MINE OF UNION PHOSPHATE COMPANY.

[East of Hot Spring House, NW. ¼ NE. ¼ sec. 24, township 15 south, range 44 east, Boise meridian.]

Sample No.	Strike.	Dip.	Thickness of strata.	Distance below Productus limestone.	Description.	P_2O_5.	$Ca_3(PO_4)_2$.
			Ft. in.	*Ft. in.* to *Ft. in.*		*Per cent.*	*Per cent.*
141-A	N. and S..	55° W.	1 6	63 0 to 64 6	Sh, br, cal, s, eff con	9.0	19.7
141-B	N. and S..	55° W.	2 8	64 6 to 67 2	Sh, mas, br, cal, t, eff con	2.0	4.4
141-C	N. and S..	55° W.	2 2	67 2 to 69 4	Ool, med, gr b, eff vig	32.8	71.8
	N. and S..	55° W.	2 2	69 4 to 71 6	Ls, h, mas (not sampled)		
141-D	N. and S..	55° W.	0 11	71 6 to 72 5	Ool, gr b, & sh, eff con	32.3	70.7
141-E	N. and S..	55° W.	1 0	72 5 to 73 5	Sh, br, h, cal, eff vig	3.5	7.7
141-F	N. and S..	55° W.	1 3	73 5 to 74 8	{10″ ool, med, b 5″ phos, sh, br b} eff con	36.3	79.5
141-G	N. and S..	55° W.	1 10	74 8 to 75 10	{5″ sh, cal 4″ ool, gr 2″ sh, br 11″ sh, br} eff con	27.5	60.2
141-H[a]	N. and S..	55° W.	5 10	75 10 to 81 8	Ool, crs, br gr, brit, eff con	29.1	63.7
141-I	N. and S..	55° W.	1 5	81 8 to 83 1	Ool, gr, crs, pebbly, eff vig	28.0	61.3
141-K	N. and S..	55° W.	11 0	83 1 to 94 1	Sh or black clay rock, eff slight	24.3	53.2
	N. and S..	55° W.	1 0	94 1 to 95 1	Ls, gr, b (not sampled)		
141-L	N. and S..	55° W.	10 6	95 1 to 105 7	Sh, t, br b, eff slight	12.9	28.3
	N. and S..	55° W.	4 11	105 7 to 110 6	Sh, cal br, (not sampled)		
141-M	N. and S..	55° W.	1 8	110 6 to 112 2	Ool, gr b, & b sh, eff slight	20.3	44.5
141-N	N. and S..	55° W.	4 6	112 2 to 116 8	Sh, br b, brit, eff slight	5.2	11.4

SERIES FROM TUNNEL SOUTHEAST FROM SPRING HOUSE.

[Samples taken from rear of tunnel, running east and west across strike, NW. ¼ NE. ¼ sec. 24, township 15 south, range 44 east, Boise meridian.]

137-A	N. and S..	42° W.	1 3	Not determined.	Ool, crs, br b, brit, eff slight	36.2	79.3
137-B	N. and S..	42° W.	0 5	Not determined.	Sh, phos, br, brit, eff slight	24.7	54.1
137-C	N. and S..	42° W.	1 8	Not determined.	Ool, crs, gr b, crm, eff slight	34.8	76.2
137-D	N. and S..	42° W.	1 8	Not determined.	Ool, gr b, brit, eff slight	37.0	81.0

[a] Lowering of phosphate content due to local shaly streaks.

WYOMING.

THOMAS FORK AREA.

The first important section examined in Wyoming was in the Sublette Range of mountains, near the Idaho border. The phosphate series is exposed in several minor canyons along the west front of this range in the northern part of Thomas Fork Valley. The dip of the beds is quite steep, varying from 35° to 85°. The overlying Productus limestone stands in sheer massive ledges, in places almost perpendicular, rising as a rock rib 50 to 100 feet above the slopes which cover the phosphate series. Samples of the phosphate rock were taken from the prospects and exposures in the various canyons for a distance of approximately 8 miles. These samples were from the northern part of township 26 and the south part of township 27, range 119 west, sixth principal meridian, Wyoming.

In township 26 good material was obtained from the claims of the Union Phosphate Company in York Canyon, between Francis and Leland canyons. On the north side of this gulch, outside of the tunnel, is an exposure of phosphate rock 4 feet 4 inches thick (38–A) containing 34.3 per cent phosphoric acid, or 73.1 per cent tricalcium phosphate. On the south side of the gulch the same bed, somewhat thicker, is slightly richer, having 35 per cent phosphoric acid, or 77 per cent tricalcium phosphate. Samples representing 16 feet of the phosphate series were obtained in this canyon. In addition to the main bed, a phosphate layer (37–A and B) 8 feet 8 inches thick, exposed above, has an average of 21.7 per cent phosphoric acid, or 47.5 per cent tricalcium phosphate.

In Francis Canyon, three-fourths of a mile south of York Canyon, there is a larger exposure of the phosphate series. In township 26 there are two main strata of phosphate rock, the upper one varying from 3 to 3½ feet in thickness and having 32.5 to 35 per cent phosphoric acid, and the other, stratigraphically a lower bed, carrying from 26 to 32 per cent phosphoric acid. These beds are separated by 40 to 50 feet of phosphatic limestones and shales. Apart from the two main beds just mentioned, the remaining material exposed in this canyon is of rather low grade. Two beds, however (the first directly above and the second directly below the lower main bed), of 8 feet 6 inches and 4 feet 2 inches, respectively (36–I and L), contain about 13 per cent phosphoric acid, or 28.5 per cent tricalcium phosphate.

In Leland Canyon only one sample was obtained, owing to the poor exposures. This was evidently one of the main beds, and has an average of 30 per cent phosphoric acid, or 65 per cent tricalcium phosphate.

In Jackson Canyon, north of Leland Canyon, only the upper (40–A) of the two main beds is exposed. It runs 32.7 per cent phosphoric acid, or 71.6 per cent tricalcium phosphate. Some of the underlying shales and limestones were sampled and found to be low in phosphate.

In Coal Canyon, north of Jackson Canyon, there is a good exposure of the phosphate series. The first good bed occurs only 9 or 10 feet below the Productus limestone (41–A) and is 3 feet 9 inches thick, the rock containing 27 per cent phosphoric acid. There is a second bed (41–H) 40 feet below the first, which is 4 feet 6 inches thick and contains 26 per cent phosphoric acid. The phosphate rock in this gulch is black, soft, and crumbly. It is of lower grade than the material found in the other gulches along the mountain range. Owing to its jet black and glossy appearance it was at first mistaken for coal; hence the name, Coal Canyon.

On the south side of Raymond Canyon, the gulch north of Coal Canyon, there are several prospects on the San Francisco Company claims. The rock here is black, oolitic, and very hard, and requires blasting to loosen it from the overlying and underlying beds. Only the upper (42–B) of the two main beds is exposed here. It is 3 feet thick, and contains 32 per cent phosphoric acid, or 70.5 per cent tricalcium phosphate. It is only 10 feet from the Productus limestone.

In township 27 there are two excellent exposures of the phosphate series, one one-half mile and the other 5 miles north of Raymond Canyon. In the first gulch a prospect runs east and west across the strike, giving an exposure of 74 feet. The main bed (35–A) is 4 feet 10 inches thick and contains 33.6 per cent phosphoric acid, or 73.6 per cent tricalcium phosphate. A short distance below there are three strata (35–C–D–E) with a combined thickness of 8 feet 8 inches, which contain an average of 25 per cent phosphoric acid, or 54.8 per cent tricalcium phosphate. Twenty-six feet below these is a 19-foot stratum of soft brown shaly material containing 20 per cent phosphoric acid, or 43.8 per cent tricalcium phosphate. The second gulch, 5 miles above, contains several prospects; one running across the strike gives a 20-foot exposure of the phosphate series. Just north of this prospect is another tunnel running in on the strike, with an exposure of the upper main bed (44). This bed is 6 feet thick, coarsely oolitic, gray in color, and contains 38.6 per cent phosphoric acid, or 84.5 per cent tricalcium phosphate. Under this bed there is a stratum 3 feet 4 inches thick. A sample (43–E) of this rock, obtained from a prospect south of 44², contained 18.4 per cent phosphoric acid, or 40.3 per cent tricalcium phosphate. Almost directly under this bed there are two others (43–F–G), aggregating 6 feet 10 inches, analyses of which give an average of 25 per cent phosphoric acid, or nearly 54 per cent tricalcium phosphate. At present the

San Francisco Chemical Company and the Union Phosphate Company are operating claims in this area.

The nearest shipping point to these phosphate beds is Border, from 4 to 12 miles distant, on the Idaho-Wyoming line. Assessment work only is being done in this section.

Table V gives the results of analyses of samples collected in this region.

TABLE V.—*Results of chemical analyses of phosphate rock in the Thomas Fork area.*

SERIES FROM FRANCIS CANYON, 3 MILES (APPROXIMATELY) SOUTH OF RAYMOND CANYON.

[First six samples taken in prospect, running east and west across strike; second six samples taken outside of prospect. NW. ¼ NE. ¼ sec. 19, township 26 north, range 119 west, sixth principal meridian, Wyoming.]

Sample No.	Strike.	Dip.	Thickness of strata.	Distance below Productus limestone.	Description.[a]	P_2O_5.	$Ca_3(PO_4)_2$.
			Ft. in.			*Per cent.*	*Per cent.*
36-A	N. 20° W.	80° E.	5 0	Not determined.	Ls, gr, h, eff vig	Trace.	Trace.
36-B	N. 20° W.	80° E.	1 6	Not determined.	Sh, gr b, h, eff con	6.4	14.0
36-C	N. 20° W.	80° E.	6 4	Not determined.	Ls, br gr, h, eff very vig	1.0	2.2
36-D	N. 20° W.	80° E.	1 0	Not determined.	Ls, gr, h, eff very vig	2.0	4.3
36-E	N. 20° W.	80° E.	9 2	Not determined.	Sh, br, s, eff con	4.2	9.2
36-F	N. 20° W.	80° E.	3 4	Not determined.	Ool, b, s, eff very slight	32.5	71.2
	N. 20° W.	80° E.	40 0	Not determined.	Covered interval (not sampled)		
36-G	N. 20° W.	80° E.	3 0	Not determined.	Sh, gr br, s, eff vig	4.0	8.8
36-H	N. 20° W.	80° E.	6 0	Not determined.	Sh, br b, s, eff vig	8.6	18.8
36-I	N. 20° W.	80° E.	8 6	Not determined.	Sh, gr b, s, eff vig	13.0	28.5
36-K	N. 20° W.	80° E.	2 4	Not determined.	Ool, b, s, eff con	32.8	71.8
36-L	N. 20° W.	80° E.	4 2	Not determined.	Sh, gr br, s, eff vig	13.3	29.1
36-M	N. 20° W.	80° E.	4 0	Not determined.	Ls, eff very vig	1.0	2.2

SERIES FROM OUTSIDE PROSPECT, SOUTH SIDE OF YORK CANYON.

[NE. ¼ SW. ¼ sec. 18, township 26 north, range 119 west, sixth principal meridian, Wyoming.]

37-A	N. 5° W.	72° E.	5 0	Not determined.	Ool (somewhat), gr br, s, eff slight	21.9	48.0
37-B	N. 5° W.	72° E.	3 8	Not determined.	Ool (somewhat), gr br, s, eff con	21.5	47.1
	N. 5° W.	72° E.	2 0	Not determined.	Ls (not sampled),		
37-C	N. 5° W.	72° E.	5 10	Not determined.	Ool, b, s, eff slight	35.0	76.7

SERIES FROM OUTSIDE PROSPECT, NORTH SIDE OF YORK CANYON.

[NE. ¼ SW. ¼ sec. 18, township 26 north, range 119 west, sixth principal meridian, Wyoming.]

38-A	N. 5° W.	72° E.	6 6	Not determined.	Ls, gr, h, eff very vig	1.7	3.7
38-B	N. 5° W.	72° E.	4 0	Not determined.	Ool, b, s, eff slight	34.3	75.1

SERIES FROM NORTH SIDE OF JACKSON CANYON.

[North half of section 7, township 26 north, range 119 west, sixth principal meridian, Wyoming.]

40-A	S. 30° W.	80° to 90°	4 6	Not determined.	Ool, b, s, eff slight	32.7	71.6
40-B	S. 30° W.	80° to 90°	4 8	Not determined.	Sh, br, s, eff very slight	4.1	9.0
40-C	S. 30° W.	80° to 90°	1 2	Not determined.	Ls, gr b, h, eff very vig	Trace.	Trace.
40-D	S. 30° W.	80° to 90°	3 8	Not determined.	Ool (somewhat) br b, s, eff vig	8.8	19.3
40-E	S. 30° W.	80° to 90°	4 0	Not determined.	Sh, gr br, s, eff vig	10.7	23.4

SERIES FROM COAL CANYON, 1 MILE (APPROXIMATELY) SOUTH OF RAYMOND CANYON.

[Sixty-seven foot exposure. NE. ¼ NW. ¼ sec. 7, township 26 north, range 119 west, sixth principal meridian, Wyoming.]

				Ft. in.	*Ft. in.*			
41-A	N. 18° W.	75° E.	3 9	9 0	to 12 9	Ool, br b, s, eff slight	27.0	59.1
	N. 18° W.	75° E.	1 0	12 9	to 13 9	Ls (not sampled)		
41-B	N. 18° W.	75° E.	8 8	13 9	to 22 5	Sh, br b, s, eff con	16.3	35.7
	N. 18° W.	75° E.	2 0	22 5	to 24 5	Ls (not sampled)		
41-C	N. 18° W.	75° E.	2 0	24 5	to 26 5	Sh, br, med h, eff very slight	Trace.	Trace.
	N. 18° W.	75° E.	1 0	26 5	to 27 5	Ls (not sampled)		
41-D	N. 18° W.	75° E.	1 3	27 5	to 28 8	Sh, br, s, eff con	11.9	26.1
	N. 18° W.	75° E.	4 0	28 8	to 32 8	Ls (not sampled)		
41-E	N. 18° W.	75° E.	8 0	32 8	to 40 8	Sh, br b, s, eff very slight	16.8	36.8
	N. 18° W.	75° E.	4 0	40 8	to 44 8	Ls, sh (not sampled)		
41-F	N. 18° W.	75° E.	6 0	44 8	to 50 8	Sh, br b, s, eff very slight	16.4	35.9
41-G	N. 18° W.	75° E.	4 0	50 8	to 54 8	Sh, gr b, s, w, eff vig	12.0	16.3
41-H	N. 18° W.	75° E.	4 6	54 8	to 59 2	Ool, ers, b, s, eff slight	26.0	56.9
41-I	N. 18° W.	75° E.	5 6	59 2	to 64 8	Ool (somewhat), b, s, eff con	19.6	42.9
41-K	N. 18° W.	75° E.	2 7	64 8	to 67 3	Ls, sh, gr b, h, eff con	10.2	22.3

SERIES FROM RAYMOND CANYON, SOUTH SIDE OF GULCH.

[NW. ¼ NE. ¼ sec. 6, township 26 north, range 119 west, sixth principal meridian, Wyoming.]

42-A	N. and S.	85° to 90° E.	4 5	0 0	to 4 5	Sh, gr br, s, eff	8.9	19.5
	N. and S.	85° to 90° E.	6 0	4 5	to 10 5	Ls, sh (not sampled)		
42-B	N. and S.	85° to 90° E.	3 1	10 5	to 13 6	Ool, b, h, eff slight	32.0	70.1
42-C	N. and S.	85° to 90° E.	5 0	13 6	to 18 6	Ls, b, h, eff con	9.3	20.4

[a] The abbreviations in this column are explained on p. 15.

TABLE V.—*Results of chemical analyses of phosphate rock in the Thomas Fork area*—Continued.

SERIES FROM PROSPECT B, FIRST GULCH NORTH OF RAYMOND CANYON.

[NW. ¼ SE. ¼ sec. 31, township 27 north, range 119 west, sixth prineipal meridian, Wyoming.]

Sample No.	Strike.	Dip.	Thickness of strata.	Distanee below Productus limestone.	Description.[a]	P_2O_5.	$Ca_3(PO_4)_2$.
			Ft. in.			*Per cent.*	*Per cent.*
35-A	N. and S.	80° to 90° E.	4 10	Not determined.	Ool (somewhat), gr b, s, eff slight	33.6	73.6
35-B	N. and S.	80° to 90° E.	3 4	Not determined.	Sh and Ls, br gr, h, eff con	11.5	25.2
35-C	N. and S.	80° to 90° E.	3 7	Not determined.	Ool, br b, s, eff very slight	28.7	62.9
35-D	N. and S.	80° to 90° E.	2 9	Not determined.	Ool, gr b, s, eff very slight	23.7	51.9
35-E	N. and S.	80° to 90° E.	2 4	Not determined.	Ool, cal, b, h, eff vig	25.8	56.5
35-F	N. and S.	80° to 90° E.	2 3	Not determined.	Ls, gr, h, eff very vig	3.2	7.0
35-G	N. and S.	80° to 90° E.	3 0	Not determined.	Sh, br b, s, eff very vig	15.5	33.9
35-H	N. and S.	80° to 90° E.	1 10	Not determined.	Ls, gr br, sh, h, eff vig	1.4	3.1
35-I	N. and S.	80° to 90° E.	3 2	Not determined.	Sh, br b, s, eff slight	5.9	12.9
35-K	N. and S.	80° to 90° E.	1 1	Not determined.	Ls, gr, h, mas, eff vig	Trace.	Trace.
35-L	N. and S.	80° to 90° E.	1 10	Not determined.	Sh, br b, s, eff slight	6.0	13.1
35-M	N. and S.	80° to 90° E.	1 0	Not determined.	Ls, gr br, h, eff very vig	Trace.	Trace.
35-N	N. and S.	80° to 90° E.	12 0	Not determined.	Sh, br b, s, eff con	12.8	28.0
35-O	N. and S.	80° to 90° E.	19 0	Not determined.	Sh, br b, s, eff slight	20.0	43.8
35-P	N. and S.	80° to 90° E.	12 0	Not determined.	Sh, gr br, s, eff con	11.0	24.1

SERIES FROM GULCH, 5 MILES (APPROXIMATELY) NORTH OF RAYMOND CANYON.

[NW. ¼ NE. ¼ sec. 19, township 27 north, range 119 west, sixth prineipal meridian, Wyoming.]

44 (*b*)	N. and S.	45° E.	6 0	Not determined.	Ool, gr b, eff very slight	38.6	84.5
43-A	N. and S.	45° E.	3 4	Not determined.	Ls, gr b, h, eff very vig	7.1	15.5
43-B	N. and S.	45° E.	0 9	Not determined.	Ool, brit, b, s, eff con	19.8	43.4
43-C	N. and S.	45° E.	1 8	Not determined.	Ool, b, brit, eff con	15.1	33.1
43-D	N. and S.	45° E.	2 6	Not determined.	Ool, med h, b, mas, eff slight	12.2	26.7
	N. and S.	45° E.	1 6	Not determined.	Ls (not sampled)		
43-E	N. and S.	45° E.	3 4	Not determined.	Ool, crs, b, s, eff con	18.4	40.3
	N. and S.	45° E.	0 4	Not determined.	Ls (not sampled)		
43-F	N. and S.	45° E.	3 6	Not determined.	Ool, b, s, eff con	21.9	48.0
43-G	N. and S.	45° E.	3 4	Not determined.	Ool (somewhat), br b, eff slight	28.6	62.6

[a] The abbreviations used in this column are explained on p. 15.

[b] Unknown interval between 44 and 43-A.

COKEVILLE AREA.

At the southern end of the Sublette Range of mountains, 2 miles east of Cokeville, Wyo., is a mine of the Union Phosphate Company. At this point Smith's Fork cuts through the lower end of the mountains and empties into the Bear River. For a distance of approximately 10 miles from Francis Canyon southward the phosphate entirely disappears from the Sublette Mountains, but reappears at the south end of the range at Coketown Butte, on the east flank of a steep anticlinal fold. Here the main bed (55–I–K) is about 65 feet below the Productus limestone. The deposit has a thickness of 5 feet 4 inches and contains over 35 per cent phosphoric acid, or 76 per cent tricalcium phosphate. It is directly overlain by 3 feet 7 inches of calcareous phosphate rock and shale (55–G–H) having an average of over 20 per cent phosphoric acid, or 44 per cent tricalcium phosphate, and underlain by 1 foot 4 inches of soft phosphatic shale (55–L), containing 24.5 per cent phosphoric acid, or 53.7 per cent tricalcium phosphate. This shale is discarded in mining. Owing to the poor exposures, no samples of the lower strata of the phosphate series were obtained in this section.

The Union Phosphate Company has opened upon the phosphate by three tunnels, one above the other, running in on the strike for a distance of several hundred feet. The mine is worked by the stoping system, the material from the upper levels descending by gravity through chutes to the main tunnel, where it is received in cars and wheeled to the bins outside, from which it is hauled 2 miles by wagon to the Oregon Short Line Railroad at Cokeville. During the last three years 6,000 tons of this rock have been shipped to San Francisco, and probably about 3,000 tons were taken out in 1909. The material is harder than at Montpelier, Idaho, blasting and compressed-air drills being employed in loosening the rock. The cost of mining and hauling the rock to the railroad is approximately $2 per ton. The material has been delivered at Cokeville at $2.50 per ton f. o. b.

About 8 miles east of Cokeville, in Pine Creek Canyon, the Carboniferous strata again outcrop, but there are no good exposures of the phosphate beds, and no prospecting has been done. One high-grade sample gave 35.5 per cent phosphoric acid, or 77.7 per cent tricalcium phosphate. Between 12 and 15 miles southeast of Cokeville, near Rock Creek, several claims have been located, but the material uncovered thus far is low grade.

Analyses for the Cokeville deposits will be found in Table VI.

TABLE VI.—*Results of chemical analyses of phosphate rocks in the Cokeville area, Wyoming.*

MINE 2 MILES EAST OF COKEVILLE, WYO.

[Tract 104, NW. ¼ sec. 4, township 24 north, range 119 west, sixth principal meridian, Wyoming.]

Sample No.	Strike.	Dip.	Thickness of strata.	Distance below Productus limestone.	Description.[a]	P_2O_5.	$Ca_3(PO_4)_2$.
			Ft. in.	*Ft. in. Ft. in.*		*Per cent.*	*Per cent.*
	N. 10° W.	62° E.	6 0	0 0 to 6 0	Concealed		
55-A	N. 10° W.	62° E.	1 0	6 0 to 7 0	Sh, cal, h, eff con	17.4	38.1
	N. 10° W.	62° E.	4 0	7 0 to 11 0	Ls, b, sil (not sampled)		
	N. 10° W.	62° E.	2 0	11 0 to 13 0	Concealed		
	N. 10° W.	62° E.	3 0	13 0 to 16 0	Ls, b (not sampled)		
	N. 10° W.	62° E.	20 0	16 0 to 36 0	Concealed		
	N. 10° W.	62° E.	1 6	36 0 to 37 6	Ls, h, b (not sampled)		
	N. 10° W.	62° E.	3 0	37 6 to 40 6	Concealed		
55-B	N. 10° W.	62° E.	1 2	40 6 to 41 8	Ool, ers, h, eff con	19.4	42.5
	N. 10° W.	62° E.	6 8	41 8 to 48 4	Concealed (probably black shale)		
55-C	N. 10° W.	62° E.	3 0	48 4 to 51 4	Sh, br, eff vig	0.4	0.9
	N. 10° W.	62° E.	0 10	51 4 to 52 2	Sh, br, cal (not sampled)		
55-D	N. 10° W.	62° E.	1 1	52 2 to 53 4	Ool, b, h, mas, eff con	28.5	62.4
55-E	N. 10° W.	62° E.	3 9	53 4 to 57 1	Sh, br, s, eff con	1.0	2.2
	N. 10° W.	62° E.	1 4	57 1 to 58 5	Ls, sh, b (not sampled)		
55-F	N. 10° W.	62° E.	1 6	58 5 to 59 11	Sh, br, s, eff slight	0.8	1.8
	N. 10° W.	62° E.	5 3	59 11 to 65 2	Sh, cal (not sampled)		
55-G	N. 10° W.	62° E.	1 11	65 2 to 67 1	Ool, grades to sh ls, eff vig	22.2	48.6
55-H	N. 10° W.	62° E.	1 8	67 1 to 68 9	Ool, h, b, cal, eff con	18.6	39.7
b55-I	N. 10° W.	62° E.	3 0	68 9 to 71 9	Ool, gr b, h, eff con	37.0	81.0
b55-K	N. 10° W.	62° E.	2 4	71 9 to 74 1	Ool, gr b, eff very slight	33.2	72.7
b55-L	N. 10° W.	62° E.	1 4	74 1 to 75 5	Sh, gr br, s, eff slight	24.5	53.7
	N. 10° W.	62° E.	0 6	75 5 to 75 11	Sh (not sampled)		
	N. 10° W.	62° E.	2 1	75 11 to 78 0	Ls, mas (not sampled)		
55-M	N. 10° W.	62° E.	1 0	78 0 to 79 0	Ool, med, gr, eff very slight	33.4	73.1
55-N	N. 10° W.	62° E.	2 2	79 0 to 81 2	1′ 11″ sh, br, somewhat ool 3″ sh, br } eff slight	19.5	42.7
55-O	N. 10° W.	62° E.	0 7	81 2 to 81 9	Ool, gr, h, cal, eff con	25.6	56.1
	N. 10° W.	62° E.	1 6	81 9 to 83 3	Sh (not sampled)		
	N. 10° W.	62° E.	1 8	83 3 to 84 11	Ool, mas (not sampled)		
	N. 10° W.	62° E.	1 0	84 11 to 85 11	Sh, br, mas (not sampled)		
	N. 10° W.	62° E.	1 7	85 11 to 87 6	Sh, br (not sampled)		
	N. 10° W.	62° E.	2 3	87 6 to 89 9	Sh, phos, w (not sampled)		
	N. 10° W.	62° E.	1 0	89 9 to 90 9	Ls, gr b (not sampled)		
	N. 10° W.	62° E.	4 2	90 9 to 94 11	Sh, h, b (not sampled)		
	N. 10° W.	62° E.	4 10	94 11 to 99 9	Ls, b, h (not sampled)		
	N. 10° W.	62° E.	3 6	99 9 to 103 3	Sh, br (not sampled)		
	N. 10° W.	62° E.	1 6	103 3 to 104 9	Ls, br gr, h, mas (not sampled)		

N. 10° W.	62° E.	1 10	104 9 to 106 4	Sh, br, b (not sampled)	
N. 10° W.	62° E.	3 6	106 7 to 110 1	Ls, br, s, earthy (not sampled)	
N. 10° W.	62° E.	2 0	110 1 to 112 1	Ls, br, w, mas (not sampled)	
N. 10° W.	62° E.	4 2	112 1 to 116 3	Sh, b (not sampled)	
N. 10° W.	62° E.	1 3	116 3 to 117 6	Ls, gr br (not sampled)	
N. 10° W.	62° E.	1 6	117 6 to 119 0	Ls, b, s (not sampled)	
N. 10° W.	62° E.	2 10	119 0 to 121 10	Sh, s, b (not sampled)	
N. 10° W.	62° E.	1 0	121 10 to 122 10	Ls, b (not sampled)	
N. 10° W.	62° E.	2 3	122 10 to 125 1	Ls, br w (not sampled)	
N. 10° W.	62° E.	3 9	125 1 to 128 10	Concealed	

[a] The abbreviations used in this column are explained on p. 15.

[b] Main bed.

BECKWITH HILLS AREA.

Fifteen miles south of Cokeville and a few miles southeast of Beckwith Station are the Beckwith Hills, upon which the phosphate lies very near the surface in broad anticlinal and synclinal folds. This deposit is promising, for though it is not as extensive as those of some other localities, it is close to the surface and has a high content of phosphoric acid. This rock differs from that in the areas previously described in that it is gray and crumbly, and contains much coarse oolitic material less crumbly. The main bed is very near the surface, and in some places has completely eroded away. In other places this bed has a thickness of from 3 to 5 feet, and contains from 34 to 36.5 per cent phosphoric acid, or 79.9 per cent tricalcium phosphate. Underlying the main bed are a number of other phosphate beds from 1 to 2 feet in thickness, between which occur strata of phosphatic shales and limestones. No material is being shipped from these claims, although the hills are only 3 or 4 miles distant from Sage Station, Wyo., on the Oregon Short Line Railroad. Several placer claims have been located in this section.

The results of analyses of samples taken in the Beckwith Hills area are given in Table VII.

TABLE VII.—*Results of chemical analyses of phosphate rocks in the Beckwith Hills area.*

SERIES FROM PAHRANIGAT LODE CLAIM (DUFFIELD & JEFFS).

[South side of first gulch containing phosphate below Beckwith ranch. SW. ¼ NW. ¼ sec. 2, township 21 north, range 120 west, sixth principal meridian, Wyoming.]

Sample No.	Strike.	Dip.	Thickness of strata.	Distance below Productus limestone.	Description.[a]	P_2O_5.	$Ca_3(PO_4)_2$.
			Ft. in.			*Per cent.*	*Per cent.*
81-A	N. 72° W.	19° N.	0 6	Not determined.	Ool, crs, gr, s, eff con	34.7	76.0
	N. 72° W.	19° N.	0 3	Not determined.	(Not sampled)		
	N. 72° W.	19° N.	0 3	Not determined.	Clay, red and yel (not sampled)		
	N. 72° W.	19° N.	0 4	Not determined.	Sh, gr, s (not sampled)		
81-B	N. 72° W.	19° N.	1 0	Not determined.	Sh, gr br, s, eff slight	27.3	59.8
	N. 72° W.	19° N.	1 7	Not determined.	Ls, h (not sampled)		
81-C	N. 72° W.	19° N.	1 6	Not determined.	Ool, crs, s, cr, eff vig	31.5	70.0
81-D	N. 72° W.	19° N.	0 9	Not determined.	Sh, gr br, s, eff vig	10.0	21.9
81-E	N. 72° W.	19° N.	2 6	Not determined.	Ool, gr b, eff slight	28.4	62.2
81-F	N. 72° W.	19° N.	0 6	Not determined.	Sh, br, eff very slight	10.6	23.2

SERIES FROM PAHCOON LODE CLAIM (DUFFIELD & JEFFS).

[North side of Twin Creek Gap. SE. ¼ SE. ¼ sec. 3, township 21 north, range 120 west, sixth principal meridian, Wyoming.]

84-A	N. 60°.	West.	1 6	Not determined.	Sh, gr, s, eff very slight	23.5	51.5
84-B	N. 60°.	West.	0 11	Not determined.	Sh, gr, s, eff none	2.7	5.9
84-C	N. 60°.	West.	0 10	Not determined.	Ool, gr, s, eff slight	33.3	72.9
84-D	N. 60°.	West.	1 7	Not determined.	Ool, gr, eff slight	23.7	51.9
84-E	N. 60°.	West.	2 7	Not determined.	4″ ool, crs, gr 2′ 3″ ool, h, gr } eff slight	25.8	56.5

SERIES FROM SOUTH SIDE OF TWIN CREEK GAP.

[Opposite No. 84. NW. ¼ SE. ¼ sec. 10, township 21 north, range 120 west, sixth principal meridian, Wyoming.]

83-A	N. 60°.	West.	3 2	Not determined.	Sh, gr, s, eff con	28.4	62.2
	N. 60°.	West.	0 4	Not determined.	Clay, red and yel (not sampled)		
	N. 60°.	West.	0 2	Not determined.	Sh, gr (not sampled)		
	N. 60°.	West.	1 1	Not determined.	Clay, red (not sampled)		
83-B	N. 60°.	West.	3 4	Not determined.	8″ ool, gr 10″ ool, reddish 1′ 10″ ool, gr } eff con	25.7	56.3

[a] The abbreviations used in this column are explained on p. 15.

TABLE VII.—*Results of chemical analyses of phosphate rocks in the Beckwith Hills area*—Continued.

SERIES FROM HANAPAH LODE CLAIM (DUFFIELD & JEFFS).

[Last prospect toward west. SW. ¼ NE. ¼ sec. 15, township 21 north, range 120 west, sixth principal meridian, Wyoming.]

Sample No.	Strike.	Dip.	Thickness of strata.	Distance below Productus limestone.	Description.[a]	P_2O_5.	$Ca_3(PO_4)_2$.
			Ft. in.			*Per cent.*	*Per cent.*
86-A	Indeterminable.	Indeterminable.	4 0	Not determined.	Ool, gr br, h, eff slight	36.5	79.9
86-B	...do.....	...do.....	2 0	Not determined.	Sh, gr, s, eff con	33.5	73.4

SERIES FROM PERCY LODE CLAIM (C. C. JONES).

[East of No. 86. SW. ¼ SE. ¼ sec. 15, township 21 north, range 120 west, sixth principal meridian, Wyoming.]

87-A	N. 50° E.	8° W.	0 9	Not determined.	Sh (mostly), s, gr br, eff vig	13.9	30.5
87-B	N. 50° E.	8° W.	3 0	Not determined.	Ool, crs, gr, brit, eff con	36.0	78.8
87-C	N. 50° E.	8° W.	0 6	Not determined.	Ool, fine, s, gr br, eff slight	23.7	51.9
87-D	N. 50° E.	8° W.	0 11	Not determined.	Ool, crs, h, gr, eff vig	34.7	76.0
97-E	N. 50° E.	8° W.	0 11	Not determined.	Sh, gr, eff slight	34.9	76.4

[a] The abbreviations used in this column are explained on p. 15.

UTAH.

CRAWFORD MOUNTAINS AREA.

The Crawford Mountains extend along or near the boundary between Wyoming and Utah north and south for a distance of 20 miles. The phosphate series in these mountains lies in a narrow synclinal fold. On the western side of the range the beds have been traced southward for about 10 miles. At this point a fault occurs, which seems to have discouraged further prospecting. Samples of the phosphate strata were taken in the various canyons along the west front of the range wherever there were any exposures. These samples were from the outcrops at either flank of the syncline and represent in some cases 100 feet of the phosphate series.

The main bed in both townships examined is from 60 to 100 feet below the Productus limestone. It is about 5 feet 4 inches in thickness, and has a 7-inch stratum of shaly phosphate, 3 feet from the top, containing only from 21 to 23 per cent phosphoric acid. This shaly material is discarded in mining the rock. The remaining 4 feet 9 inches contains (with one exception) from 32 to 37 per cent phosphoric acid, or 70 to 80 per cent tricalcium phosphate. Directly under this main bed is a stratum of soft phosphatic shale, from 9 inches to 5½ feet thick, containing from 22 to 31 per cent phosphoric acid.

In Brazer Canyon (township 11) on the east flank of the syncline which extends through the mountain range a section of the phosphate series was sampled. Here several strata of phosphate rock are exposed below the main bed. They occur as follows: About 10 feet under the main bed is a stratum (97–E) of hard gray oolitic rock, 1 foot 9 inches thick, containing 26.8 per cent phosphoric acid, or 58.7 per cent tricalcium phosphate. Under this and separated from it by 8 feet of cherty limestone is a stratum (97–F) of calcareous phosphate, 1 foot 2 inches thick, containing 28.7 per cent phosphoric acid, or 62.8 per cent tricalcium phosphate. Over 70 feet under this stratum are two beds of phosphate (98–A–B), aggregating 4 feet 5 inches in thickness, containing 25 per cent phosphoric acid, or 54.8 per cent tricalcium phosphate.

About 2,000 tons of phosphate rock are being shipped annually to Los Angeles, Cal., from the Arickaree lode claim in township 12. The main tunnel of this mine runs north and south for a distance of 400 feet; a lateral tunnel runs 22 degrees west from this for 200 feet along the strike. The beds have a steep westerly dip, so the material is mined by the overhead stoping and caving system. The rock is hauled by wagon 7 miles to the railroad at Sage Station, Wyo. Only the main bed (93–A–B–C) and a few inches of very high grade shaly

material (93–E) underlying it were sampled here. The cost of mining the material is approximately $1.25 per ton, and hauling $2 per ton. The freight rates to California are the same as from Montpelier and Cokeville. A number of other claims in this section are being worked only to meet the requirements of the assessment law.

The results of analyses for the Crawford Mountains area are given in Table VIII.

TABLE VIII.—*Results of chemical analyses of phosphate rocks in Crawford Mountains area, Wyoming–Utah.*

SERIES FROM OPEN CUT ALMOST DIRECTLY EAST OF ENBERG RANCH, 7 MILES SOUTHWEST OF SAGE, WYO. EAST FLANK OF SYNCLINE.

[Lot 5, SE. ¼ sec. 32, township 12 north, range 8 east, Salt Lake principal meridian, Utah.]

Sample No.	Strike.	Dip.	Thickness of strata.	Distance below Productus limestone.	Description.[a]	P_2O_5.	$Ca_3(PO_4)_2$.
			Ft. in.			*Per cent.*	*Per cent.*
92-A	N. 27° E.	44° W.	1 0	Not determined.	Sh, br, h, eff vig	1.0	2.2
	N. 27° E.	44° W.	5 9	Not determined.	Sh, br, cal (not sampled)		
92-B	N. 27° E.	44° W.	1 4	Not determined.	Pebbly mat, h, gr, eff slight	10.7	23.4
	N. 27° E.	44° W.	0 9	Not determined.	Sh, cal (not sampled)		
92-C	N. 27° E.	44° W.	0 7	Not determined.	Ool, crs, gr, eff slight	30.5	66.8
	N. 27° E.	44° W.	1 0	Not determined.	Sh, h (not sampled)		
92-D	N. 27° E.	44° W.	3 7	Not determined.	Ool, crs, gr, eff slight	35.7	78.2
	N. 27° E.	44° W.	0 3	Not determined.	Sh, br (not sampled)		
92-E	N. 27° E.	44° W.	1 8	Not determined.	Ool, gr, h, eff con	36.4	79.7

SERIES FROM ARICKAREE MINE (BRADLEY BROTHERS).

[Seven miles southwest of Sage, Wyo. Lot 1, NE. ¼ sec. 32, township 12 north, range 8 east, Salt Lake principal meridian, Utah.]

93-A	N. 32° E.	50° W.	1 9	Not determined.	Ool, crs, gr, h, eff con	29.4	64.4
93-B	N. 32° E.	50° W.	1 4	Not determined.	Ool, fine, gr, h, eff slight	37.6	82.3
93-C	N. 32° E.	50° W.	0 7	Not determined.	Sh, grades to ool, br, h	21.4	46.9
93-D	N. 32° E.	50° W.	1 0	Not determined.	Ool, med, gr, h, eff slight	38.0	82.3
93-E	N. 32° E.	50° W.	0 9	Not determined.	Sh, phos, gr, s, eff slight	34.6	75.8

SERIES FROM MANDAN LODE CLAIM (BRADLEY BROTHERS), WEST OF ARICKAREE MINE.

[Lot 1, NE. ¼ sec. 32, township, 12 north, range 8 east, Salt Lake principal meridian, Utah.]

95	N. 24° E.	82° W.	4 6	Not determined.	3′ 6″ ool, crs, gr 8″ sh, phos. } eff vig 1′ 6″ ool, fine gr	33.8	74.0
96-G	N. 24° E.	82° W.	0 9	Not determined.	Sh, cal, gr, s, eff con	31.5	69.0
	N. 24° E.	82° W.	4 1	Not determined.	Sh, br, s, cal (not sampled)		
96-F	N. 24° E.	82° W.	1 9	Not determined.	Sh, gr br, h, eff vig	13.5	29.6
96-E	N. 24° E.	82° W.	0 10	Not determined.	Ool, crs, gr, brit, eff vig	30.6	67.0
	N. 24° E.	82° W.	1 1	Not determined.	Ls, gr (not sampled)		
96-D	N. 24° E.	82° W.	1 6	Not determined.	Ool, gr, h, eff slight	25.9	56.7
96-C	N. 24° E.	82° W.	3 3	Not determined.	Ool and sh, mat alternating	29.4	64.3
	N. 24° E.	82° W.	1 6	Not determined.	Sh, br, h (not sampled)		
96-B	N. 24° E.	82° W.	1 3	Not determined.	Ool, crs, gr, h, eff vig	31.0	67.9
	N. 24° E.	82° W.	2 5	Not determined.	Ls, gr, h (not sampled)		
96-A	N. 24° E.	82° W.	1 6	Not determined.	Ool, gr, h, cal, eff vig	24.9	54.5

[a] The abbreviations used in this column are explained on p. 15.

TABLE VIII.—*Results of chemical analyses of phosphate rocks in Crawford Mountains area, Wyoming–Utah*—Continued.

SERIES FROM BRAZER CANYON, 4 MILES EAST OF RANDOLPH, UTAH. EAST FLANK OF SYNCLINE.

[NE. ¼ NE. ¼ sec. 19, township 11 north, range 8 east, Salt Lake principal meridian, Utah.]

Sample No.	Strike.	Dip.	Thickness of strata.	Distance below Productus limestone.	Description.[a]	P_2O_5.	$Ca_3(PO_4)_2$.
			Ft. in.	*Ft. in.* *Ft. in.*		*Per cent.*	*Per cent.*
97-A	N. 16° E.	46° W.	3 2	100 0 to 103 2	Ool, crs, gr, h, eff con	34.9	76.4
97-B	N. 16° E.	46° W.	0 8	103 2 to 103 10	Sh, phos, br, eff slight	23.7	51.9
97-C	N. 16° E.	46° W.	1 2	103 10 to 105 0	Ool, med, br, h, eff slight	36.8	80.6
97-D	N. 16° E.	46° W.	5 8	105 0 to 110 8	Sh, phos, br, h, eff slight	31.0	67.9
	N. 16° E.	46° W.	4 8	110 8 to 115 4	Concealed, traces of sh (not sampled)		
97-E	N. 16° E.	46° W.	1 8	115 4 to 117 0	Ool, med, gr, h, eff con	26.8	58.7
	N. 16° E.	46° W.	8 0	117 0 to 125 0	Ls, cherty (not sampled)		
97-F	N. 16° E.	46° W.	1 2	125 0 to 126 2	Ool, h, gr, cal, eff con	28.7	62.8
	N. 16° E.	46° W.	71 6	126 2 to 197 8	Concealed (not sampled)		
98-A	N. 16° E.	46° W.	2 10	197 8 to 200 6	1′ 5″ sh, br, s 4″ ool, gr, s eff con 1′ sh, br, s	23.4	51.2
98-B	N. 16° E.	46° W.	1 7	200 6 to 202 1	Ool, gr, s, eff con	27.8	60.3

SERIES FROM BRAZER CANYON, 4 MILES EAST OF RANDOLPH, UTAH. WEST FLANK OF SYNCLINE.

[NW. ¼ SE. ¼ sec. 18, township 11 north, range 8 east, Salt Lake principal meridian, Utah.]

100-A	N. and S.	East....	3 8	60 0 to 63 8	Ool, crs, gr, h, eff con	32.7	71.6
100-B	N. and S.	East....	5 2	63 8 to 68 10	Sh, cal, br, med, h, eff slight	26.3	57.6
	N. and S.	East....	0 6	68 10 to 69 4	Ls (not sampled)		
100-C	N. and S.	East....	1 6	69 4 to 70 10	Ool, crs, br gr, brit, eff	26.7	58.5

SERIES FROM FIRST CANYON NORTH OF BRAZER CANYON. EAST FLANK OF SYNCLINE.

[Prospect on north side of gulch. NW. ¼ NW. ¼ sec. 17, township 11 north, range 8 east, Salt Lake principal meridian, Utah.]

111-A	N. 10° E.	66° W.	1 6	Not determined.	Sh, phos, grades to ls, h, eff vig	16.3	35.7
111-B	N. 10° E.	66° W.	3 8	Not determined.	Ool, crs, h, gr, eff con	33.3	72.9
111-C	N. 10° E.	66° W.	0 7	Not determined.	Sh, phos, h, brit, br, eff con	18.2	39.9
111-D	N. 10° E.	66° W.	1 6	Not determined.	Ool, crs, h, grades to sh, s, eff vig	32.9	72.1
111-E	N. 10° E.	66° W.	5 0	Not determined.	Sh, s, br, eff con	29.2	63.9
	N. 10° E.	66° W.	2 4	Not determined.	Ls, sh, br (not sampled)		
111-F	N. 10° E.	66° W.	2 2	Not determined.	Ool, med h, eff con	25.4	55.6
111-G	N. 10° E.	66° W.	0 7	Not determined.	Sh, phos, s, br, eff slight	16.9	37.0
111-H	N. 10° E.	66° W.	1 0	Not determined.	Ool, sh, grades to sh, h, eff slight	26.9	58.9

SERIES FROM FIRST CANYON NORTH OF BRAZER CANYON. WEST FLANK OF SYNCLINE.

[Samples from open cut on north side of gulch. NE. ¼ NE. ¼ sec. 8, township 11 north, range 8 east, Salt Lake principal meridian, Utah.]

112–A	N. 12° E.	68° E.	1 4	Not determined.	Ool, gr, h, eff vig	20.7	45.3
	N. 12° E.	68° E.	1 4	Not determined.	Sh, br, cal (not sampled)		
	N. 12° E.	68° E.	0 4	Not determined.	Ls, br, h (not sampled)		
112–B	N. 12° E.	68° E.	1 0	Not determined.	Sh, h, br, cal, eff vig	5.8	12.7
112–C	N. 12° E.	68° E.	3 2	Not determined.	Ool, crs, gr. h, eff vig	25.7	56.3
112–D	N. 12° E.	68° E.	0 7	Not determined.	Sh, br, med h, eff con	16.6	36.4
112–E	N. 12° E.	68° E.	0 11	Not determined.	Ool, gr, h, eff vig	32.5	71.2

SERIES FROM THIRD CANYON SOUTH OF BLACKFOOT CANYON. HARRY LODE CLAIM (DUFFIELD & JEFFS).

[Prospect on north side of gulch, west flank of syncline. SW. ¼ NW. ¼ sec. 8, township 11 north, range 8 east, Salt Lake principal meridian, Utah.]

106–A	N. 15° E.	51° E.	3 2	Not determined.	Ool, crs, gr, h, eff con	32.9	72.1
106–B	N. 15° E.	51° E.	0 8	Not determined.	Sh, br, h, grades to ool, mat, eff con	21.3	46.6
106–C	N. 15° E.	51° E.	1 7	Not determined.	Ool crs, gr. b, eff slight	31.7	69.4
106–D	N. 15° E.	51° E.	1 3	Not determined.	2″ sh, br, s. 10″ ool, h, br } eff con 3″ sh, b, s..	22.8	49.9
106–E	N. 15° E.	51° E.	3 2	Not determined.	11″ ool, fine gr, s 1″ sh, s, br..... } eff very slight 2′ 3″ sh, phos.....	26.8	58.7
106–F	N. 15° E.	51° E.	0 10	Not determined.	Sh, br, b, s, eff	10.8	23.7
	N. 15° E.	51° E.	13 8	Not determined.	Sh, ls and ool, alternating (not sampled)		
106–G	N. 15° E.	51° E.	0 11	Not determined.	5″ ool, crs, b.. 4″ ool, med, gr } eff very slight 2″ ool, fine....	25.0	54.8
	N. 15° E.	51° E.	32 3	Not determined.	Sh and ls (not sampled)		

SERIES FROM COAL CANYON. PROSPECT FARTHEST NORTH, EAST FLANK OF SYNCLINE.

[NE. ¼ SW. ¼ sec. 8, township 11 north, range 8 east, Salt Lake principal meridian, Utah.]

108–A	N. 10° E.	53° W.	4 1	Not determined.	Ool, crs, gr, w, med h, eff con	35.2	77.1
108–B	N. 10° E.	53° W.	0 9	Not determined.	Sh, phos, med h, eff con	19.1	41.8
108–C	N. 10° E.	53° W.	1 10	Not determined.	1′ 1″ ool, fine, h, brit 9″ ool, fine, s..... } eff slight	31.3	68.5
	N. 10° E.	53° W.	0 3	Not determined.	Sh, cal (not sampled)		
	N. 10° E.	53° W.	1 10	Not determined.	Ls, gr b (not sampled)		
108–D	N. 10° E.	53° W.	1 10	Not determined.	Sh, phos, br, s, eff slight	25.7	54.3

[a] The abbreviations used in this column are explained on p. 15.

TABLE VIII.—*Results of chemical analyses of phosphate rocks in Crawford Mountains area, Wyoming-Utah*—Continued.

SAMPLE (ONLY ONE) FROM COAL CANYON, WEST FLANK OF SYNCLINE (MINED MATERIAL).

[NE. ¼ SE. ¼ sec. 7, township 11 north, range 8 east, Salt Lake principal meridian, Utah.]

Sample No.	Strike.	Dip.	Thickness of strata.	Distance below Productus limestone.	Description.[a]	P_2O_5.	$Ca_3(PO_4)_2$.
			Ft. in.			*Per cent.*	*Per cent.*
109	.....	East	4 8	Not determined.	3′ 1″ ool, ers, gr. 7″ sh, phos... 1′ ool, fine, gr eff slight	35.3	77.3

SERIES FROM SECOND CANYON BELOW ENBERG RANCH.

[Samples from most eastern prospect, east flank of syncline. SW. ¼ SE. ¼ sec. 5, township 11 north, range 8 east, Salt Lake principal meridian, Utah.]

103-A	17° to 22° E.	45° E.	1 6	Not determined.	Ool, h, br, eff very slight	23.8	52.1
	17° to 22° E.	45° E.	1 1	Not determined.	Sh, yel (not sampled)		
103-B	17° to 22° E.	45° E.	0 6	Not determined.	Ool, gr b, eff very slight	29.7	65.0
	17° to 22° E.	45° E.	1 2	Not determined.	Sh, yel, med h (not sampled)		
103-C	17° to 22° E.	45° E.	5 9	Not determined.	Ool, ers, gr, eff very slight	32.2	70.5
(*b*) 105	17° to 22° E.	45° E.	2 8	Not determined.	Ool, ers, grades to ool, fine, gr, eff slight	29.6	64.8

SERIES FROM SECOND CANYON BELOW ENBERG RANCH.

[Samples from second prospect in second series, east flank of syncline. SW. ¼ SE. ¼ sec. 5, township 11 north, range 8 east, Salt Lake principal meridian, Utah.]

104-A	N. and S.	60° W.	1 3	Not determined.	Ool, br b, somewhat sh, eff vig	16.6	36.4
104-B	N. and S.	60° W.	1 9	Not determined.	Sh, br, cal, eff vig	7.2	15.8

SERIES FROM SECOND CANYON BELOW ENBERG RANCH.

[Samples from second prospect on north side of gulch, west flank of syncline. Lot 14, ¼ sec. 5,[c] township 11 north, range 8 east, Salt Lake principal meridian, Utah.]

102-A	N. 20° E.	48° E.	4 2	Not determined.	Sh, br, brit, eff con	8.1	17.7
	N. 20° E.	48° E.	1 6	Not determined.	Ls, gr (not sampled)		
102-B	N. 20° E.	48° E.	3 10	Not determined.	Sh, gr b, h, cal, eff vig	17.3	37.8
	N. 20° E.	48° E.	4 7	Not determined.	4″ ls, ers, gr 1″ sh, br... 2″ ool..... 4′ ls, sh.... not sampled		
102-C	N. 20° E.	48° E.	2 7	Not determined.	Sh, br b, brit, eff vig	16.7	36.6
	N. 20° E.	48° E.	2 1	Not determined.	Ls, b, cherty (not sampled)		
102-D	N. 20° E.	48° E.	1 6	Not determined.	Sh, br, s, eff slight	13.0	28.5
	N. 20° E.	48° E.	4 2	Not determined.	Sh and ls (not sampled)		
102-E	N. 20° E.	48° E.	4 0	Not determined.	Ool, s, b, eff very slight	25.9	56.7

SERIES FROM FIRST CANYON SOUTH OF ENBERG RANCH.

[First prospect on north side of gulch, west flank of syncline. Lot 11, ¼ sec. 5, township 11 north, range 8 east, Salt Lake principal meridian, Utah.]

101	N. 23° E.	53° E.	2 3	Not determined.	Ool, h, cal, grades to ls, eff con	14.7	32.2
	N. 23° E.	53° E.	0 2	Not determined.	Sh, brit, gr (not sampled)		
	N. 23° E.	53° E.	2 4	Not determined.	Ls, h, b (not sampled)		

[a] The abbreviations used in this column are explained on p. 15.

[b] Unknown interval between 103-C and 105.

[c] Measurements are approximate owing to faulty structure.

WOODRUFF CREEK AREA.

The next area examined was west of the town of Woodruff, Utah. The phosphate beds near the canyon bottoms are here much faulted and broken, and the hills are covered with a Tertiary conglomerate, the Wasatch formation. In this section a mine has been opened by the San Francisco Chemical Company, about 12 miles west of the town. The entrance to the mine was badly caved and only poor samples of the phosphate strata could be obtained. Some pieces picked from an old dump, however, were much richer, though still too lean to be of commercial value. Assessment work is being done here principally in repairing the road to Woodruff. Since these phosphate deposits are too far from the railroad—Evanston, Wyo., the nearest shipping point, being about 25 miles away—it is doubtful whether mining will pay for many years to come.

The analytical data are shown in the following table:

TABLE IX.—*Results of chemical analyses of phosphate rocks in Woodruff area, Utah.*

[Township 8 north, range 5 east, Salt Lake principal meridian, Utah.]

Sample No.	Location.	Strike.	Dip.	Thickness of strata.	Distance below Productus limestone.	Description.[a]	P_2O_5.	$Ca_3(PO_4)_2$.
				Ft. In.			*Per cent.*	*Per cent.*
120	Sample of material collected at random from surface of dump of old mine (San Francisco Chemical Co.) center of sec. 16.	.....	.....	.....	.....	Ool, h, b, eff slight.....	23.7	51.9
121	Sample from old entry of mine; lower end of road from Road Hollow. Sec. 16.	.....	.....	2 0	Not determined.	Sh, br b, s, eff slight.....	12.1	26.5
122	Sample of stripping from S. end of Woodruff Creek Claims. NW. ¼ NW. ¼ sec. 21.	.....	.....	.....	Not determined.	Sh, b, brit, eff con.....	15.2	33.3

[a] The abbreviations used in this column are explained on p. 15.

LAKETOWN AREA.

On the north side of old Laketown Canyon, 1 mile east of the mouth, there is an overturned anticline, and a fault zone, bringing the phosphate against the Mississippian limestone. A much crushed bed of phosphate along this fault is the only one that had been recognized by local prospectors. The exposures of phosphatic strata in this canyon are poor—only 6 feet 7 inches of the series were obtained by digging a trench on beds that had not before been prospected. Much of this material is rich in phosphoric acid. The rock is very coarsely oolitic, of a medium gray color, and quite crumbly. It resembles the material found in the Beckwith Hills. There has been comparatively little prospecting done in this section, though a few claims have been located. Laketown is reached by stage from Montpelier, Idaho, a distance of approximately 40 miles, and the nearest railroad station is Dingle, Idaho, about 28 miles away and 8 miles from the north end of Bear Lake. In time the lake, which is navigable, will probably be used for transporting the material.

Results of analyses and other data are given in Table X.

TABLE X.—*Results of chemical analyses of phosphate rocks in the Laketown area, Utah.*

[Township 13 north, range 6 east, Salt Lake principal meridian, Utah.]

Sample No.	Location.	Strike.	Dip.	Thickness of strata.	Distance below Productus limestone.	Description.[a]	P_2O_5.	$Ca_3(PO_4)_2$.
				Ft. In.			*Per cent.*	*Per cent.*
131	Sample of phosphate float from east side of anticline in old Laketown Canyon. NW. ¼ NE. ¼ sec. 32.	.....	.....	.....	.....	Ool, crs, gr, h, eff slight.....	34.3	75.4
132	Samples from open cut taken next to evident fault zone, old Laketown Canyon. SE. ¼ NW. ¼ sec. 32.	.....	.....	0 9	Not determined.	Ool, br b, eff con.....	31.8	69.6
134-A	Series from old Laketown Canyon. NW. ¼ NE. ¼ sec. 32.	.....	.....	1 5	Not determined.	Ool, crs, crm, gr, eff slight.....	36.3	79.5
	.....do.....	.....	.....	0 4	Not determined.	Sh, br (not sampled).....	.....	.....
134-B	.....do.....	.....	.....	0 5	Not determined.	Ool, crs, crm, eff slight.....	37.3	81.7
134-C[b]	.....do.....	.....	.....	0 5	Not determined.	Ool (mostly), f, h, eff slight.....	26.4	57.8
134-D	.....do.....	.....	.....	0 6	Not determined.	Ool, crs, crm, gr, eff slight.....	36.7	80.4
134-E	.....do.....	.....	.....	0 8	Not determined.	Sh, gr red, s, eff con.....	26.0	56.5
134-F	.....do.....	.....	.....	2 10	Not determined.	Ool, med, s, eff con.....	34.1	74.7

[a] The abbreviations used in this column are explained on p. 15.

[b] Poor sample; contained soil.

COMPARISON OF THE WESTERN PHOSPHATE WITH THAT FROM OTHER SOURCES.

Table XI gives the percentage of phosphoric acid and tricalcium phosphate in rock from various localities in Idaho, Wyoming, and Utah. Table XII gives similar data for phosphate rock and guano from other important domestic and foreign fields.[a] The comparison shows that these western deposits are among the richest in the world.

TABLE XI.—*Samples from main phosphate beds, Idaho-Wyoming-Utah.*

State.	Sample No.	Thickness of strata.	Township and section.	P_2O_5.	$Ca_3(PO_4)_2$.
		Ft. in.		*Per cent.*	*Per cent.*
Idaho	144-S	6 4	Township 10, what would be sec. 30 (unsurveyed).	36.8	80.6
Do	139-C, D, E, F	6 4	Township 14, SE. ¼	34.9	76.4
Do	141-H	5 10	Township 15, NW. ¼ NE. ¼ sec 24.	[b] 29.1	[b] 63.7
Do	29	4 9	Township 12, NE. ¼ SE. ¼ sec. 30.	33.5	73.4
Do	31-A	4 5	Township 12, NW. ¼ NE. ¼ sec. 31.	35.3	77.3
Do	33	4 10	do	34.4	75.1
Do	5	5 0	Township 13, SW. ¼ sec. 6	34.8	76.2
Do	8	5 0	do	35.2	77.1
Do	14	4 6	Township 13, SW. ¼ NE. ¼ sec. 6.	36.1	79.1
Do	21	5 10	do	37.7	82.6
Wyoming	36-F	3 4	Township 26, NW. ¼ NE. ¼ sec. 19.	32.5	71.2
Do	37-C	5 10	Township 26, NE. ¼ SW. ¼ sec. 18.	35.0	76.7
Do	38-B	4 0	do	34.3	75.1
Do	34	4 6	Township 27, NW. ¼ NE. ¼ sec. 31.	31.7	69.4
Do	35-A	4 10	do	33.6	73.6
Do	44	6 0	Township 27, NW. ¼ NE. ¼ sec. 19.	38.6	84.5
Do	45-A, B	5 4	Township 24, tract 104, NW. ¼ sec. 4.	35.0	76.7
Do	55-A, B	5 4	do	35.5	77.7
Do	82	6 0	Township 21, SE. ¼ NW. ¼ sec. 2.	36.6	80.2
Do	85	5 6	do	36.0	78.8
Do	86-A	4 0	Township 21, SW. ¼ NE. ¼ sec. 15.	36.5	79.9
Do	87-B	3 0	Township 21, SW. ¼ SE. ¼ sec. 15.	33.5	73.4
Do	88	2 10	Township 21, SW. ¼ NE. ¼ sec. 15.	36.7	80.4
Utah	92-D	3 7	Township 12, lot 5, SE. ¼ sec. 32.	35.7	78.2
Do	93-A, B	3 1	Township 12, lot 4, NE. ¼ sec. 32.	33.5	73.4
Do	94	4 0	do	37.7	82.6
Do	95	4 6	Township 12, lot 1, NE. ¼ sec. 32.	33.8	74.0
Do	103-C	5 9	Township 11, SW. ¼ SW. ¼ sec. 5.	32.2	70.5
Do	108-A	4 1	Township 11, NE. ¼ SW. ¼ sec. 8.	35.2	77.1
Do	106-A	3 2	Township 11, SW. ¼ NW. ¼ sec. 8.	32.9	72.1
Do	107	3 10	Township 11, near W. ¼ cor. of sec. 8.	32.5	71.2
Do	111-B	3 8	Township 11, NW. ¼ NW. ¼ sec. 17.	33.3	72.9
Do	99	5 0	Township 11, NW. ¼ SW. ¼ sec. 17.	34.7	76.0
Do	100-A	3 8	Township 11, NW. ¼ SE. ¼ sec. 18.	32.7	71.6
Do	134-B, C, D, E, F.	4 10	Township 8, NW. ¼ NE. ¼ sec. 32.	32.0	70.1

[a] Taken from Amer. Fertil. Handbook, 1908, p. 72, and Bul. 94, Agr. Dept. of Pennsylvania.
[b] Low phosphate content due to local streaks of shale.

TABLE XII.—*Phosphate rock and guanos from various sources.*

	P_2O_5.	$Ca_3(PO_4)_2$.
	Per cent.	*Per cent.*
Algerian phosphate	29 to 32	63 to 70
Apatite	36 to 39	80 to 85
Caribbean guano	19	42
Florida hard rock	35 to 37	78 to 80
Florida land pebble	31 to 33	68 to 73
Florida Peace River	22 to 30	58 to 63
Guilbert Islands phosphate	36 to 39	80 to 85
Orchilla guano	26.8	59
Peruvian guano	13.5	30
South Carolina rock (ground)	25 to 27	55 to 60
South Carolina rock (floats)	28	62
Slag phosphate (American)	21	46
Slag phosphate (German)	30	66
Tennessee phosphate	35 to 37	78 to 80
Tunisian phosphate	26 to 29	58 to 63

MANUFACTURE OF FERTILIZERS.

At present all the phosphate rock mined in the Idaho-Wyoming-Utah area is sent to California for fertilizer manufacture. The material is handled by factories at Los Angeles and at Stege and Martinez, near San Francisco.

All the factories are run in connection with sulphuric-acid plants. Part of the acid is made by roasting calcopyrite containing about 2 per cent of copper and 48 per cent of sulphur. The ash is treated for the recovery of the copper, either by leaching with water or by smelting. Another method for the manufacturing of sulphuric acid is by the use of high-grade Japanese sulphur. It is estimated that the total daily capacity of these and adjacent plants is very close to 100 tons of 52° Baumé acid.

In the manufacture of phosphate the phosphate rock may be used either raw or mixed with bat guano or dried blood before treatment with sulphuric acid. The usual proportions are about 9 parts of acid to 10 parts of the rock, ground so as to pass through a 30-mesh sieve. After the escape of the carbon dioxide, hydrofluo-silicic acid, and other gases, the material solidifies to a porous mass. It is claimed that there is an improvement in the superphosphate during storage of as much as 1 per cent of soluble phosphoric acid. The total capacity of these plants is estimated at 175 tons per day, but as yet the demand in California is below that figure, and the manufactories are not running at their full capacity.

The product of these concerns is put on the market in three forms. "Basic" superphosphate is made by piling acid phosphate and quicklime in alternate layers and allowing the whole to stand for several days. The finished product, which is said to be largely dicalcium phosphate, is used by farmers who wish to avoid the use of acidified fertilizers. Other farmers prefer the acidified superphosphate. The third form in which the superphosphate is used is in mixtures with

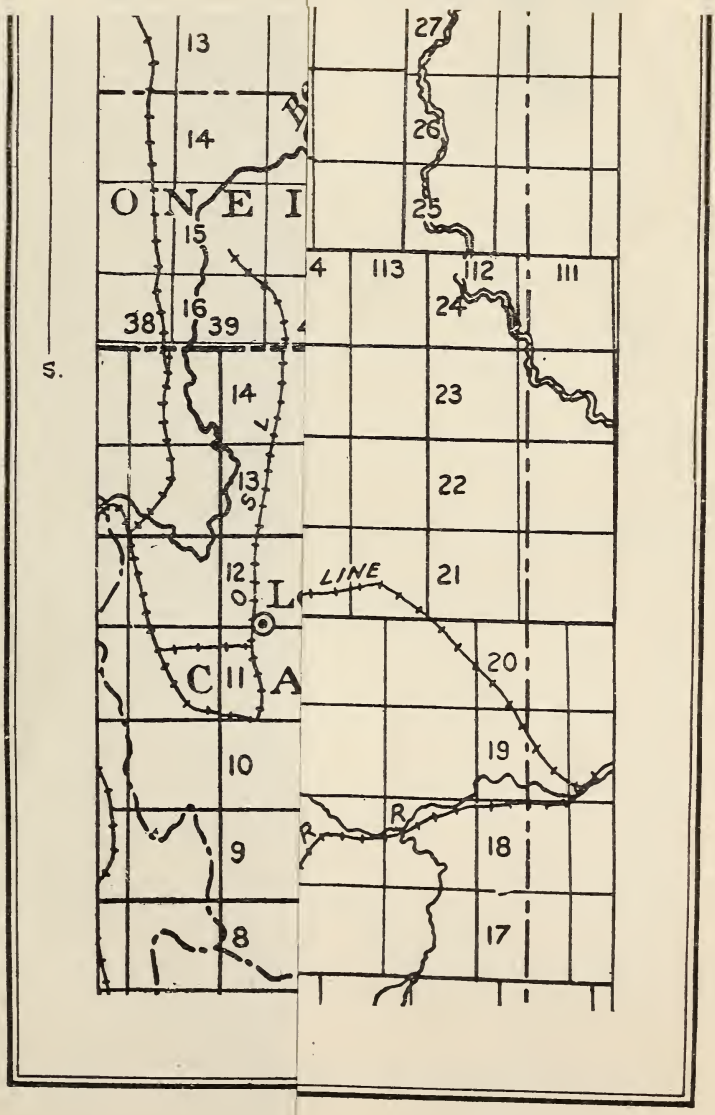
potash and nitrogen carriers. Besides the three factories already referred to, there are others which use the crude superphosphate in the manufacture of special brands of mixed fertilizers.

The consumption of fertilizers in California is steadily growing, having increased from 10,000 to 35,000 tons during the last four years. As yet the principal consumption is in the citrus-fruit belt of southern California and in grain-growing sections of the State the use of superphosphate is increasing. Superphosphates are sold on a basis of the so-called "available" phosphoric acid determined by the solubility of the phosphate in certain citrate solutions.[a] The wholesale price in California is 65 cents per unit of phosphoric acid and the retail price $1 per unit. In other words, material sold on a guaranty of 17 per cent of available P_2O_5 brings $17 a ton.

OUTLOOK FOR THE FUTURE.

There is little prospect that the western phosphates will be extensively mined in the near future owing to the great distances to present markets. However, with the growing demand in the West for fertilizers and the gradual depletion of the more accessible deposits, these western fields will undoubtedly come more and more into prominence. It would seem obvious that the utmost care should be exercised in granting mining rights, and, if possible, these rights should be granted with such control over the mining operations as to prevent wanton waste of lower-grade deposits which, though not at present of value for fertilizer manufacture, will be utilized at a more remote date.

[a] Bul. 107, Bureau of Chemistry, p. 3; Leavens, Geo. D. A discussion of methods for Determining the Availability of Phosphoric Acid in Thomas Phosphate Powder, p. 31–39.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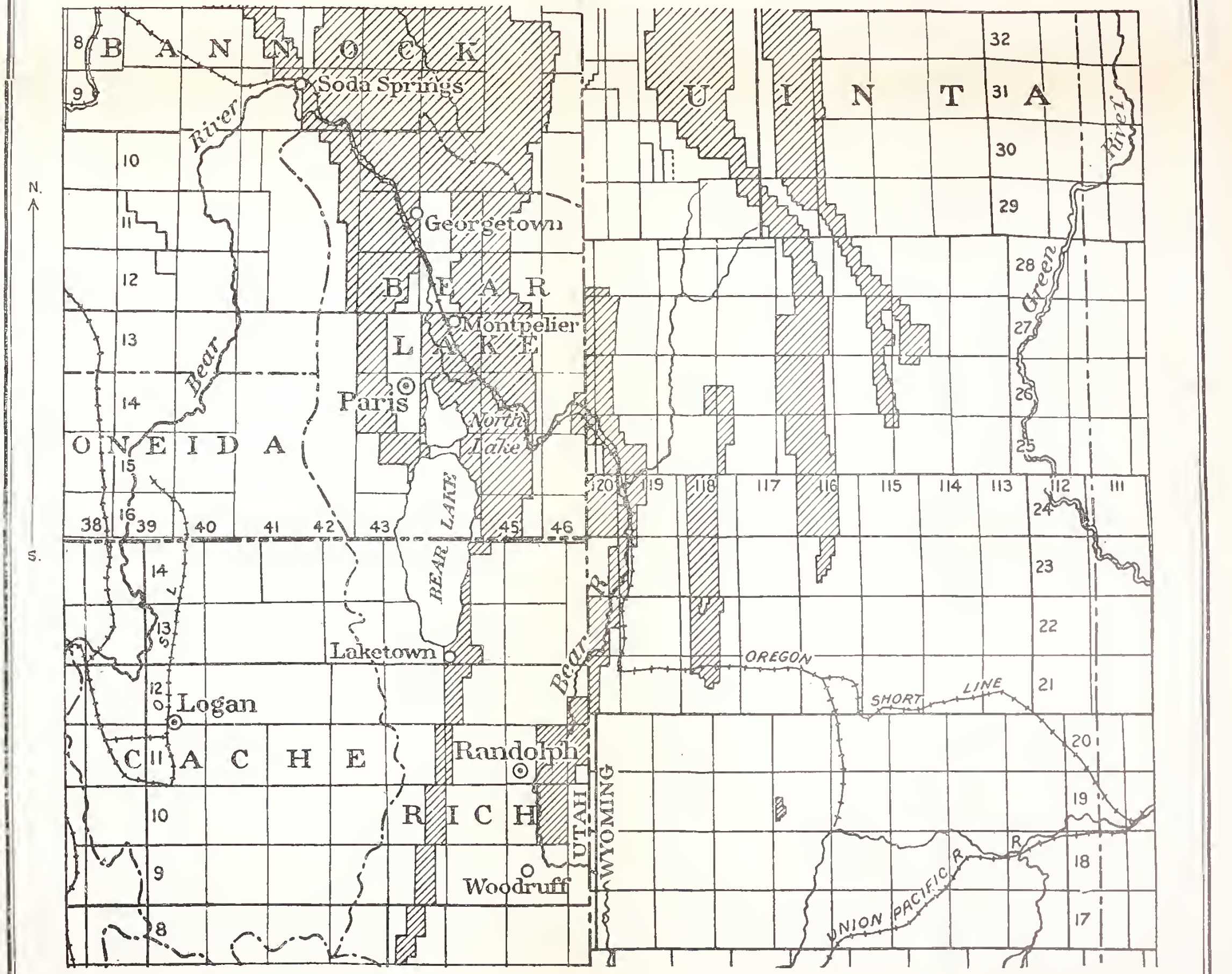

SKETCH MAP SHOWING LOCATION OF PHOSPHATE DEPOSITS IN IDAHO, UTAH, AND WYOMING.